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THE CEPHALOPOD GENERA CYRTENDOCERAS AND OELANDOCERAS.

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The generic term *Cyrtendoceras* was proposed by Adolf Remele in 1886 for a fragment of a cephalopod for which however he never supplied a specific name. Several years ago the Remele collection came into the possession of the Museum of Natural History at Berlin, and the specimen upon which Remele founded his genus *Cyrtendoceras* was loaned to the writer for study. It is described here under the name *Cyrtendoceras remelei*. This specimen is by no means the best, among those known at present, to serve as a genotype, but it is at least adequate, and therefore is here accepted.

In 1892, Gerhard Holm described two species under the names *Endoceras* (*Cyrtocerina*) *hircus* and *Endoceras* (*Cyrtocerina*) *schmidti*, which evidently are congeneric with Remele's type of *Cyrtendoceras*. These also were borrowed for study.

In the U. S. National Museum there is a fourth species of this genus, here described under the name *Cyrtendoceras estoniense*.

In addition, Dr. Gustaf Troedsson called to my attention the presence of certain cephalopods in the collections of the Royal Museum of Natural History and of the Geological Survey of Sweden, both at Stockholm, which agree with *Cyrtendoceras* in the location of the siphuncle on the concave side of the curved conch, but differ in the relatively much smaller size of these siphuncles. These specimens are described here under the names *Oelandoceras haelluddenense*, *Oelandoceras byrumense*, and *Oelandoceras kristdalaense*.

In 1906 Dr. Rudolf Ruedemann described a species under the name *Cyrtendoceras* (?) *priscum*, but the reference of this species to the genus *Cyrtendoceras* is indicated in the original

description as doubtful, and on that account the latter can scarcely be cited as the first named species *definitely* referred to *Cyrtendoceras*. It is a much smaller form, strongly coiled, and, in the opinion of the present writer, is generically distinct.

For the loan of the various specimens here cited, the writer is indebted to Dr. W. O. Dietrich, Dr. Gustaf Troedsson, Dr. R. S. Bassler, and Dr. Rudolf Ruedemann. Their kindness is greatly appreciated.

All of the species here described came from the Orthoceras limestone of the Baltic areas of Europe. In American terminology their horizon is approximately Chazyan, but no more definite correlation is possible since no trace of the fauna of the Orthoceras limestone has been discovered so far anywhere in American areas.

Both *Cyrtendoceras* and *Oelandoceras* have their siphuncles located on the concave side of the conch, and therefore are endogastric. In *Cyrtendoceras* the septal necks extend backward for a length of one camera and then invaginate into the tops of the necks immediately beneath. Within the camerae they present concave vertical outlines. Their structure, therefore, is holochoanoidal and their relationship is with the Endoceratida.

In *Oelandoceras*, on the contrary, the septal necks appear to be short, and to terminate within the upper part of the camerae. The gap between the successive septal necks is occupied by thin connecting rings which extend downward from the lower margin of one septal neck and invaginate at the base into the neck immediately beneath. These connecting rings do not present concave vertical outlines. If this interpretation of their structure is correct, *Oelandoceras* presents an ellipochoanoidal structure, similar to that of the Orthochoanites of Hyatt.

There is a possibility that the ellipochoanoidal structure of *Oelandoceras* developed from the holochoanoidal structure of forms similar to *Cyrtendoceras*. In holochoanoidal forms the septa appear to grow backward from the septa from which they orignate. In *Oelanderocas* the upper part of the septal neck, which develops first, is thicker than the lower part, which develops later. The thinner part apparently corresponds to the connecting ring of ellipochoanoidal conchs. It is not always possible to determine definitely whether a certain conch presents holochoanoidal or ellipochoanoidal structure, and the subject merits further study.

The original description of *Cyrtendoceras*, as presented by Remele, is here republished, in free translation.

Cyrtendoceras (Remele) Foerste.

Tageblatt der 59. Versammlung Deutscher Naturforscher und Aertzte zu Berlin vom 18.–24. September, 1886, p. 338 (1886).

Mr. Remele exhibits a peculiar curved cephalopod from Ordovician drift in the vicinity of Wriezen (in the Province of Brandenburg). This fossil, which is of fair size, represents a new generic type, called *Cyrtendoceras* by the speaker. In addition to a strong sickle-like curvature, exactly as in *Cyrtoceras*, the conch exhibits a very gradual increase in size, as well as very numerous camerae. Most remarkable of all, however, is the location of the siphuncle in the immediate vicinity of the concavely curved side of the conch. This siphuncle agrees with that of the vaginate orthoceroids (*Endoceras* Hall) not only in its marginal location, but also in its structure, since it is girdled by oblique transverse annulations which indicate the lower ends of the backward directed septal funnels, and which occur at intervals equal to those between the septa.

The drift material enclosing this conch is a limestone, chiefly of a light greenish-gray color, but locally with light brownish-gray parts, and with isolated yellowish plates of calcite. Among other fossils it contains, as more noteworthy, also *Echinosphaerites aurantium* Gyllenhal sp., *Illaenus centaurus* Angelin, and *Orthoceras barrandei* Dewitz. The two fossils named last indicate that this rock belongs to the Swedish Upper Gray *Orthoceras* limestone, although it differs in appearance from that usually presented by the rock of this horizon.

This specimen on which Remele founded his genus *Cyrtendoceras* is described in the following lines under the name *Cyrtendoceras remelei.*

The *Illaenus centaurus* Angelin is not identical with that of Dalman, and its name was changed by Gerhard Holm to *Illaenus chiron.*

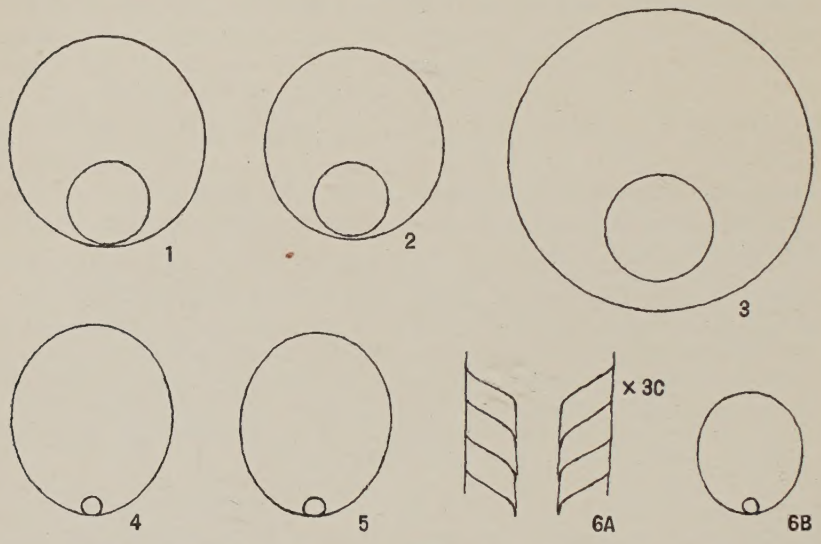
Cyrtendoceras remelei sp. nov.

(Plate II, Figures 2 A, B, C.)

Specimen approximately 45 mm. long when measured along its convex outline. Curved lengthwise, its radius of curvature along its convex outline being 40 mm. Its dorsoventral outline enlarges from 18 mm. at its base to 21 mm. at a point 37 mm. farther up. Its lateral diameter appears to be only from 1.5 to 2 mm. less than its dorsoventral one. The cross-section is more narrowly rounded along the convex side of the conch than along its concave side. There are 6 camerae in a length equal to the dorsoventral diameter of the conch. The sutures of the septa curve faintly downward laterally. The concavity of the upper septa equals almost 5 mm. Where the dorsoventral diameter of the conch is 21 mm., that of the siphuncle is 9 mm. The

latter is circular in cross-section, and its distance from the adjacent wall of the conch is at least 0.5 mm. The shell is thin and its surface appears to have been weakly annulated, though the evidence for this is not clear.

Occurrence.—Found in a loose boulder at Eberswalde, Germany; evidently from some locality in the Ordovician in the Baltic area. Label dated May 23, 1884. In the light gray Orthoceras limestone, the horizon with typical Lituitidae.



Sections Showing Location and Relative Size of Siphuncles.

1. *Cyrtendoceras hircus*, section 50 mm. above base. (Plate I, Figs. 1 A, B.)
2. *Cyrtendoceras estoniense*, section at top of type. (Plate II, Figs. 3 A, B.)
3. *Cyrtendoceras schmidti*, section 30 mm. above base. (Plate I, Figs. 2 A, B.)
4. *Oelandoceras byrumense*, section 32 mm. above base. (Plate II, Figs. 1 A, B.)
5. *Oelandoceras kristdalense*, section at base. (Plate II, Figs. 4 A, B, C.)
6. *Oelandoceras haelluddenense:* A, transverse vertical section, magnified 3 diameters, but not including entire width of conch; B, section 38 mm. above base. (Plate I, Figs. 3 A, B.)

The rock fragment containing the *Cyrtendoceras remelei* contains also a straight conch which may be the straightened part of a *Lituites lituus;* also a conch with a coiled portion 30 mm. in diameter from which the living chamber continues tangentially for a length of 20 mm., the surface striae being directly transverse, identified as *Lituites procerus* Remele (Text figure 7) on the label; and, finally, a small orthoceroid with central siphuncle, which may be a fragment of *Orthoceras barrandei* Dewitz, as identified by Remele. (Plate II, figure 5.)

Remarks.—The siphuncle of this species differs from that of *Cyrtendoceras hircus* and *Cyrtendoceras estoniense* in not being in actual contact with the concave side of the conch, though only slightly removed from the latter. On the contrary, it differs from that of *Cyrtendoceras schmidti* in being much closer to this side, the interval in the latter species being about 3 or 4 mm. From the latter species, *Cyrtendoceras remelei* differs by traces of weak annulation, both on the surface of the shell and also on the cast of its interior; and the number of camerae within a length equal to the dorsoventral diameter is relatively greater at an earlier stage of growth.

This specimen is selected here as the genotype, thus conforming, as far as possible, with the intentions of Remele.

7. *Lituites procerus* Remele; lateral view.

Cyrtendoceras hircus (Holm).

(Plate I, Figures 1 A, B; Text Figure 1.)

Endoceras (*Cyrtocerina*) *hircus* Holm. Geol. Foren. i Stockholm Forhandl., vol. 14, p. 127, pl. 4, figs. 1–3; pl. 5, figs. 1–5 (1892).

Holotype 115 mm. long when measured along its convex outline. Curved lengthwise, the lower half of its convex outline having a radius of 40 mm., changing to 52 mm. along its upper half. Only the basal part of the living chamber, for a length of 6 mm., is preserved. The dorsoventral diameter enlarges from 18.5 mm. at the base of the specimen to 36 mm. at the base of the living chamber, the corresponding lateral diameters being estimated at 17 mm. and 30 mm. The number of camerae in a length equal to the dorsoventral diameter of the conch varies from 5 at the lower end of the specimen to 7.3 at its top. The siphuncle is large, compared with the dorsoventral diameter of the conch, its dorsoventral diameter increasing from 8 mm. at its lower

end to 13 mm. at its top. The cross-section of the siphuncle is assumed to have been circular. The concavity of the septa varies from 4.5 mm. at the lower end of the specimen to 9 mm. at its top. The septal necks curve convexly inward for the greater part of their vertical outlines, changing to convexly outward a short distance before invaginating into the top of the neck directly beneath. In consequence, the segments of the siphuncle within the camerae present concave vertical outlines. The thickness of the shell varies from 0.2 mm. along its convex outline to 0.5 mm. along its concave one. Its surface is transverse striated and weakly ribbed or annulated. Their course is almost directly transverse, the downward curvature along the convex side of the conch being slight. The striae are relatively low and broad, and number 9 or 10 in a length of 10 mm. The annulations are only weakly defined, and vary from 4 in a length of 10 mm. at 50 mm. above the base of the specimen to about 2 in 10 mm. farther up, their distances apart being somewhat irregular.

Occurrence.—Vedby, in Oeland, Sweden; in the gray Lituites limestone member of the Orthoceras limestone. No. *Mo. 4493*, Riksmuseum, Stockholm, Sweden.

Remarks.—At the base of the holotype the upper part of an endocone apparently is preserved for a length of at least 2 camerae. Where the dorsoventral diameter of the siphuncle is 8 mm., that of the endocone is scarcely 6 mm. In figure 5 on Plate V of the publication by Holm, cited above, there is an endocone figured for a length of 25 mm., its lower end probably having been at least 5 mm. longer.

Cyrtendoceras estoniense sp. nov.

(Plate II, Figures 3 A, B; Text Figure 2.)

Holotype 93 mm. long when measured along its convex outline. Curved lengthwise, with a radius of 60 mm. along the lower part of its convex outline, changing to 120 mm. toward its top. The dorsoventral diameter enlarges from 10 mm. at its base to 24.5 mm. at a point 90 mm. farther up. The corresponding lateral diameters are estimated as being about the same, the cross-section being either circular or nearly so. At the base of the specimen is a single camera 2 mm. long, indicating 5 camerae in a length equal to the dorsoventral diameter of the conch. At its top the septal necks indicate the presence of 5 camerae in a length of 26 mm. At the base of the specimen the diameter of the siphuncle is 3.5 mm., while at the top it varies between 8 and 9 mm., being widest at the septa. At the lower end of the specimen this siphuncle is in contact with the concave side of the conch, while at its top it is 1 mm. distant. The septal necks present concave vertical outlines within each of the camerae. Along midlength a long endocone, or rather the solidified matrix or spiculum filling its interior, is exposed. Apparently this spiculum is 32 mm. long, but its surface continues to show faint annulations for some distance below the point at which it becomes free

from the inner walls of the siphuncle. The surface of the shell is distinctly but not strongly annulated, the annulations being directly transverse. At its lower end there are slightly over 5 annulations in a length equal to the dorsoventral diameter of the conch, this number being exactly 5 at its top. In addition, the surface of the shell is transversely striated, 9 striae occupying a length of 2 mm. at the base of the specimen, but 12.5 mm. at its top. At its base they are closely crowded; at its top they are widely separated, the intervals between the striae being much greater than the width of the latter.

Occurrence.—From some unknown locality in Estonia. Labelled as coming from the Vaginatenkalk of Schmidt, the horizon B 3, to which the name Kunda formation is applied by Raymond. No. 84762, U. S. National Museum.

Cyrtendoceras schmidti (Holm).

(Plate I, Figures 2 A, B; Text Figure 3.)

Endoceras (*Cyrtocerina*) *schmidti* Holm. Geol. Foren. i Stockholm Forhandl., vol. 14, p. 129, pl. 6, figs. 1, 2 (1892).

Holotype 120 mm. long when measured along its convex outline. Curved lengthwise, the lower half of its convex outline having a radius of 70 mm., changing to 80 mm. along its upper part. Only a part of the phragmacone is at hand, and there is no distinct shortening of its upper camerae to indicate that the conch had reached its gerontic stage. The specimen is broken in such a way that the concave outline of the conch is not preserved; however, its dorsoventral diameter is estimated to have increased from 34 mm. at its base to 44 mm. at its top. The corresponding lateral diameters are estimated at 30 mm. and 40 mm. The number of camerae in a length equal to the dorsoventral diameter of the conch is about 4.5 along the entire specimen. The sutures of the septa curve slightly downward laterally. The concavity of the upper septa equals about 13 mm. The diameter of the siphuncle can be estimated only at mid-length of the specimen, this diameter being approximately 14 mm. where that of the conch is about 39 mm. As far as can be determined from the holotype, the siphuncle was not in contact with the concave side of the conch, but was between 3 and 4 mm. distant from the latter. The surface of the shell, as far as preserved, appears to be smooth.

Occurrence.—Kandel, in Estonia; in the Echinosphaerites limestone, at the horizon C 1a. No. *Mo. 4492*, Riksmuseum, Stockholm, Sweden.

Remarks.—The structure of the siphuncle appears to be similar to that of *Cyrtendoceras hircus*. The septal necks curve inward for the greater part of the length of a camera, and then curve convexly outward just before invaginating into the top of the neck beneath. However, in *Cyrtendoceras hircus* the siphuncle is in contact with the concave wall of

conch, while in *Cyrtendoceras schmidti* it appears to have been free by an interval of several millimeters. Both conchs evidently completed more than one volution (possibly one and a half), but the apical end did not come in contact with the nearest part of the following volution.

Oelandoceras gen. nov.

Genotype: *Oelandoceras haelluddenense* Foerste.

Conch curved lengthwise, moderately compressed laterally. Camerae short, with the sutures of the septa rising toward the convex outline of the conch. Siphuncle relatively small, in contact with the concave side of the conch, its location being endogastric. The vertical outlines of the segments of the siphuncle are straight or only slightly concave, their lower margins invaginating into the top of the septal necks immediately beneath. The septal necks are short and appear to be slightly thicker than the connecting rings, the latter forming the greater part of the length of the segments of the siphuncle. This structure is most distinct in the genotype, the other two species, here referred to the same genus, not exhibiting the structure of the siphuncle equally well.

Oelandoceras haelluddenense sp. nov.

(Plate I, Figures 3 A, B; Text Figures 6 A, B.)

Holotype about 52 mm. long when measured along its convex outline, all of this length belonging to the phragmacone. Curved lengthwise, its radius of convex curvature varying from 20 mm. at the lower end of the specimen to 39 mm. at its top. Its dorsoventral diameter enlarges from 8.7 mm. near its base to 18 mm. at a point 50 mm. farther up. The corresponding lateral diameters are 7.1 mm. and 16 mm. Along the upper part of the specimen 8 camerae occur in a length equal to the dorsoventral diameter. The sutures of the septa curve slightly downward laterally, but rise higher toward the convex outline of the conch than toward the concave outline. In consequence, the sutures of the saddles on this convex side tend to be slightly angulate along their median line. The concavity of the septa is 3 mm. where the dorsoventral diameter of the conch is 16 mm. Here the diameter of the siphuncle is 2 mm. The septal necks are about two-fifths of the length of the camerae, and the connecting rings are thinner, lighter colored, and apparently cylindrical in form. The siphuncle apparently is in contact with the concave wall of the conch. The surface of the shell is striated transversely, the striae curving increasingly downward in a direction toward the convex outline of the conch, forming a broad, shallow sinus on that side, but where crossing the siphuncular side of the conch they curve downward more narrowly, forming a shallow sinus 6 or 7 mm. wide at the top of the specimen.

Occurrence.—On Oeland, at Haelludden, near Torp, in the glauconite member of the gray Vaginitenkalk. Collected by Gerhard Holm in 1893. In the paleontological collection of the Geological Survey of Sweden.

Oelandoceras byrumense sp. nov.

(Plate II, Figures 1 A, B; Text Figure 4.)

Holotype 75 mm. long when measured along its convex outline. Curved lengthwise, its radius of curvature being 60 mm. along the lower half of its convex outline, changing to 100 mm. toward its top. Its dorsoventral diameter enlarges from 22 mm. at a point 10 mm. above its base to 29.5 mm. at the bottom of the living chamber, which is 52 mm. farther up. Where the dorsoventral diameter of the conch is 28.5 mm. its lateral one is 24 mm. Here about 10 camerae occur in a length equal to the dorsoventral diameter, and the diameter of the siphuncle is slightly over 3 mm. The siphuncle is in direct contact with the concavely curved side of the conch. The sutures of the septa curve distinctly downward on approaching the siphuncle and also laterally, the saddles rising higher on the antisiphonal side of the conch than along its siphonal side. Of the living chamber a length of 16 mm. remains. The shell at this point appears to be thick and transversely striated. The structure of the siphuncle appears to be similar to that of *Oelandoceras haelluddenense*, but its details are not distinctly defined.

Occurrence.—On Oeland, at Byrum, in the glauconite bearing layer in the Vaginatenkalk. Collected by Gerhard Holm in 1891. In the paleontological collection of the Geological Survey of Sweden.

Remarks.—This species is readily distinguishable from *Oelandoceras haelluddenense* by its larger size and smaller lengthwise curvature.

Oelandoceras kristdalaense sp. nov.

(Plate II, Figures 4, A, B, C; Text Figure 5.)

Holotype 40 mm. long when measured along its convex outline. Curved lengthwise, its radius of curvature along this convex outline being about 100 mm. Its dorsoventral diameter enlarges from 25 mm. at the base of the specimen to 30 mm. at a point 18 mm. farther up. The corresponding lateral diameters are 20 mm. and 23.6 mm. Immediately below the level at which the dorsoventral diameter is 30 mm. there are about 11 camerae in a corresponding length. The sutures of the septa curve downward slightly laterally and also along the upper part of the concave side of the conch, but rise distinctly along its convex side, forming broad saddles here. The siphuncle is about 3 mm. in diameter where the dorsoventral diameter of the conch is 30 mm., and is in contact with the concave side of the conch. Its structure appears similar to that of *Oelandoceras haelluddenense* but with a more concave curvature along the upper part of the vertical outline of its segments. Its structure is not clearly defined. The surface of the shell is almost smooth, but with distant transverse lines parallel to the sutures of the septa and about equal to the latter in number; also relatively distant vertical lines; both sets of lines very faint.

Occurrence.—In Smoland, Kristadala, Humlenaes; from some unknown horizon, but assumed to belong to the glauconite bearing layer of the Vaginatenkalk, since green glauconite grains are relatively abundant in the matrix. No. *Mo. 4491*, in the Riksmuseum, Stockholm, Sweden.

Remarks.—This specimen evidently is closely related to *Oelandoceras byrumense*, and may belong to the same species, but it appears less curved lengthwise than the latter at the same diameter of the conch.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. *Cyrtendoceras hircus* (Holm). A, dorsoventral section through the siphuncle; B, weathered exterior with traces of transverse markings on surface of shell. Vedby, in Oeland, Sweden; in the gray Lituites limestone member of the Orthoceras limestone. No. *Mo. 4493*, Riksmuseum, Stockholm, Sweden. (Text Figure 1.)

Fig. 2. *Cyrtendoceras schmidti* (Holm). A, exterior surface, exposing parts of the camerae; B, dorsoventral section through the siphuncle, resulting from a break; concave outline of siphuncle reached only along lower part of specimen. Kandel, Estonia; in the Echinosphaerites limestone immediately over the Orthoceras limestone, in horizon C 1 a. No. *Mo. 4492*, Riksmuseum, Stockholm, Sweden. (Text Figure 3.)

Fig. 3. *Oelandoceras haelluddenense* Foerste. A, concave ventral side of conch; B, lateral side. At Haelludden, near Torp, on Oeland, Sweden; in the glauconite member of the gray Vaginitenkalk or Orthoceras limestone. Museum of Geological Survey of Sweden. (Text Figures 6 A, B.)

Plate II.

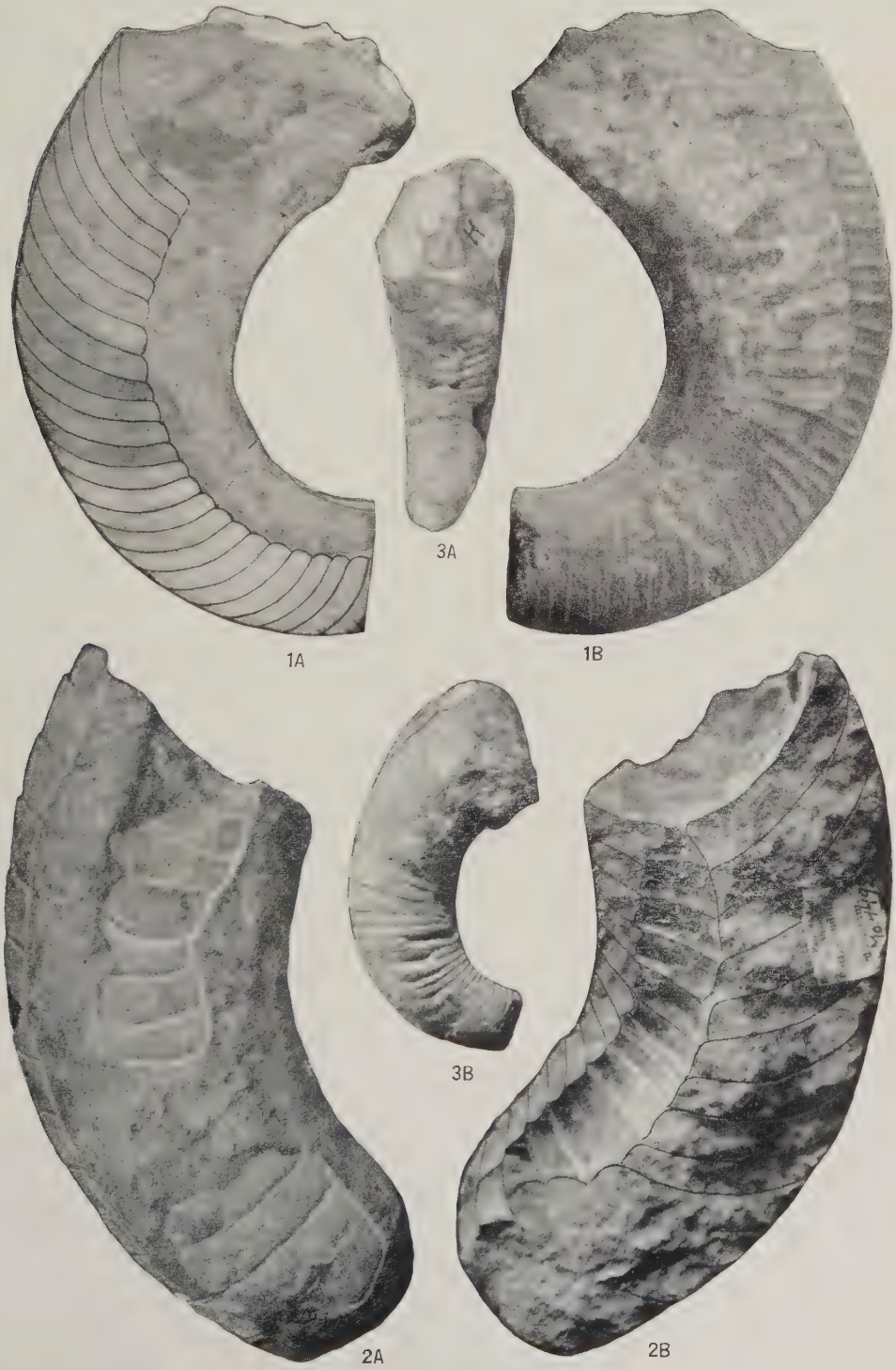
Fig. 1. *Oelandoceras byrumense* Foerste. A, convex dorsal side; B, lateral view. Byrum, on Oeland, Sweden; in the glauconite bearing member of the Vaginatenkalk. Museum of Geological Survey of Sweden. (Text Figure 4.)

Fig. 2. *Cyrtendoceras remelei* Foerste. A, lateral view; B, lower half of fragment, viewed from above, showing location of siphuncle close to concave ventral side of conch; C, cross-section, oriented as in preceding figure. In erratic boulder found at Eberswalde, northern Germany; in the upper gray member of the Orthoceras limestone. Museum of Natural History, Berlin, Germany.

Fig. 3. *Cyrtendoceras estoniense* Foerste. A, lateral view; B, dorsoventral vertical section, showing greater part of length of siphuncle, with endocone at middle, and one camera at base. From unknown locality in Estonia, labelled as from the Vaginatenkalk of Schmidt, at horizon B3. No. *84762*, U. S. National Museum. (Text Figure 2.)

Fig. 4. *Oelandoceras kristdalaense* Foerste. A, left lateral side; B, right lateral side; C, convex dorsal side; B, C, with faint transverse and vertical surface markings. Smoland, Kristdala, Humlenaes; from glauconite bearing layer in Vaginatenkalk. No. *Mo. 4491*, Riksmuseum, Stockholm, Sweden. (Text Figure 5.)

Fig. 5. *Orthoceras (?) barrandei* Dewitz. In same rock fragment as the type of *Cyrtendoceras remeli*, and the specimen of *Lituites procerus* Remele shown in Text Figure 7.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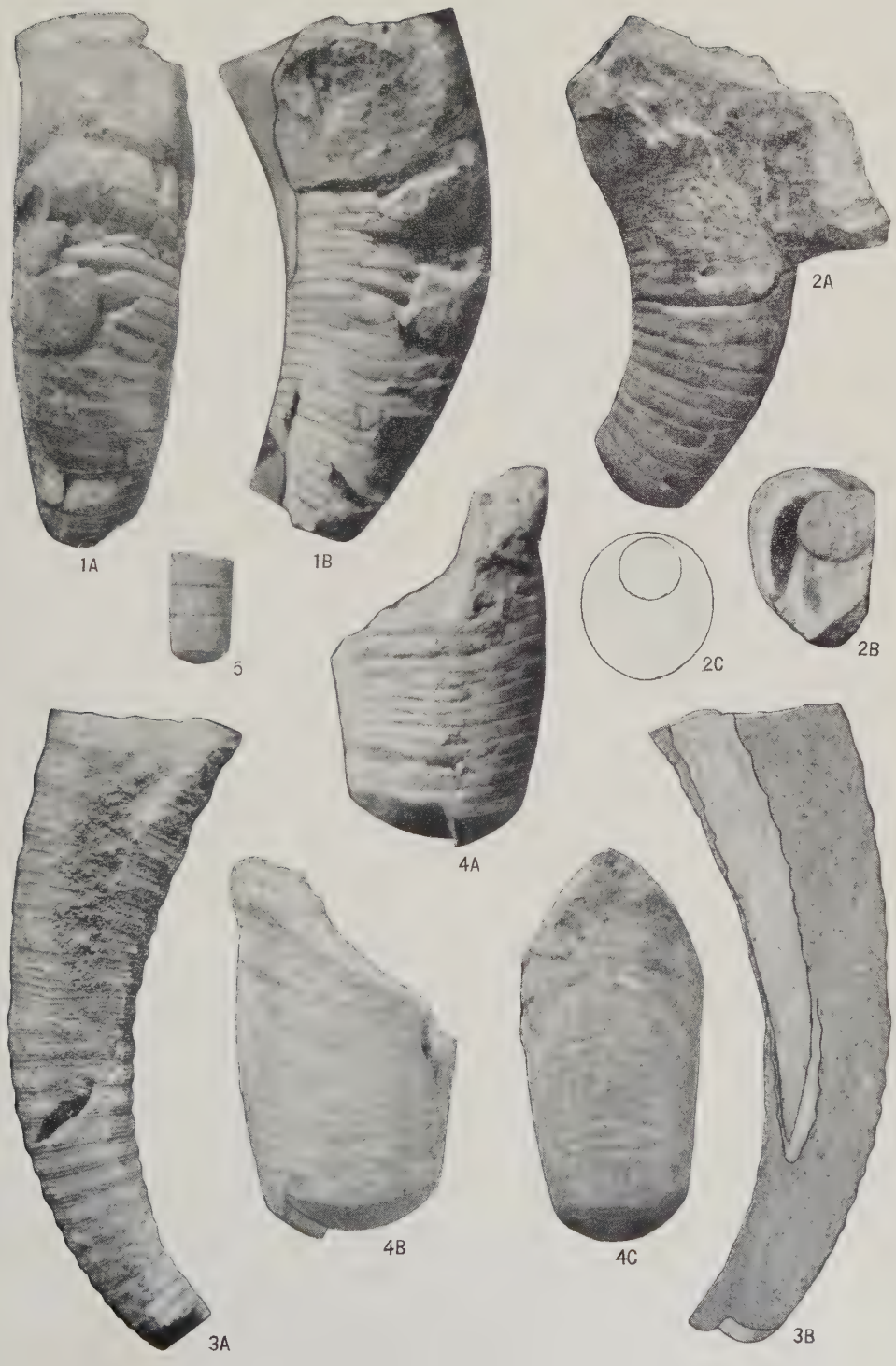
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NELSON LEDGE STATE PARK.

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INTRODUCTION.

It occurred to the writer that more should be known by the public of the scenery of Ohio and especially of the parks of the State. Little has been done to bring to the attention of the people the natural beauty and features of scientific interest in the parks. For that reason we hope to stimulate more enthusiasm in the appreciation of the natural wonders of Ohio.

Much credit is due State Forester Edmund Secrest, and other public-spirited citizens for their tireless efforts to preserve the beauty spots and forest lands for the benefit of the public and future generations. Let us hope that the work which they began will be carried to completion in the near future.

The map (Fig. 1), accompanying this paper shows the location of the trails and places in the park. The writer wishes to acknowledge the aid received from his assistants George Crowl and George Yunck of the Geology Department of Wooster College, and Arthur Murray and Malcolm McNutt of Wooster.

HISTORICAL.

Before the coming of the white man, the region in the vicinity of Nelson Ledge was the hunting ground of the Indians. That it was a favorite haunt of the red man is indicated by the fact that many implements have been found in the locality. Cornelius Baldwin, an early settler, who owned the first farm to the south, where the ledge begins, was an ardent collector of Indian relics. Fifty years ago the Baldwin collection was presented to Hiram College where it is on display in the museum.

In 1870 Nelson Ledge experienced a gold rush. It was reported that gold had been discovered in the rock formations. But it was soon learned that the yellow crystals were not gold but iron pyrite, commonly known as "Fool's Gold."

FIG. 1. Map of Nelson Ledge State Park, showing trails, locations and boundary lines.

For many years Nelson Ledge has been known as one of the natural wonders of Ohio. Constant urging by interested parties, who were anxious to preserve it in its natural state, led to its purchase in 1925 as a State park.

LOCATION, DRAINAGE AND TOPOGRAPHY.

Nelson Ledge State Park is located in the extreme northeastern township of Portage County, two and one half miles from the point where Portage, Geauga and Trumbull counties meet. It lies about five miles from Garrettsville and approximately three miles from Parkman, and can be easily reached by paved roads which lead from Cleveland, Youngstown and Akron.

In the broad valley to the east of Nelson Ledge, not far from Cascade Falls Hotel, is located the continental divide. Two streams, Cascade Creek and Sylvan Creek flow through the park; each has a beautiful cascade in its course, and arises on the upland in a glacial marsh, located about a quarter of a mile west of the Ledge. These creeks join to form a tributary that flows northward into the Grand River, which flows from Parkman through a deep, narrow gorge for a distance of about two or more miles, the waters ultimately reaching Lake Erie. To the south of the divide, a stream referred to on the map as Nelson Ditch flows south to join Tinker Creek, the waters of which ultimately flow into the Mahoning River, a tributary of the Ohio.

The State of Ohio comprises two major topographic divisions, the Erie Plain in the northwest, occupying about one-fourth of its area and the Allegheny Plateau in the east and southeast, occupying nearly all the rest of the State. Portage County lies in the northern extension of the Allegheny Plateau in Ohio. This upland is really the western continuation of the plateau, covering New York and western Pennsylvania. It has been deeply trenched by the Grand River and its tributaries on the north, and the Mahoning River on the south.

From Thompson Ledge in Thompson Township, Geauga County, the eastern outcrop of the Sharon Conglomerate, in general, follows a nearly north and south line, with indentations across Thompson, Montville, Huntsburg, Middlefield, and Parkman Townships in Geauga County and Nelson Township in Portage County, when it turns southeasterly across Windham Township. Along this north and south escarpment there are

various ledges and glens affording exposures of the Sharon Conglomerate; the best known is Nelson Ledge. Kennedy Ledge, located a mile directly east of Nelson Ledge is considered

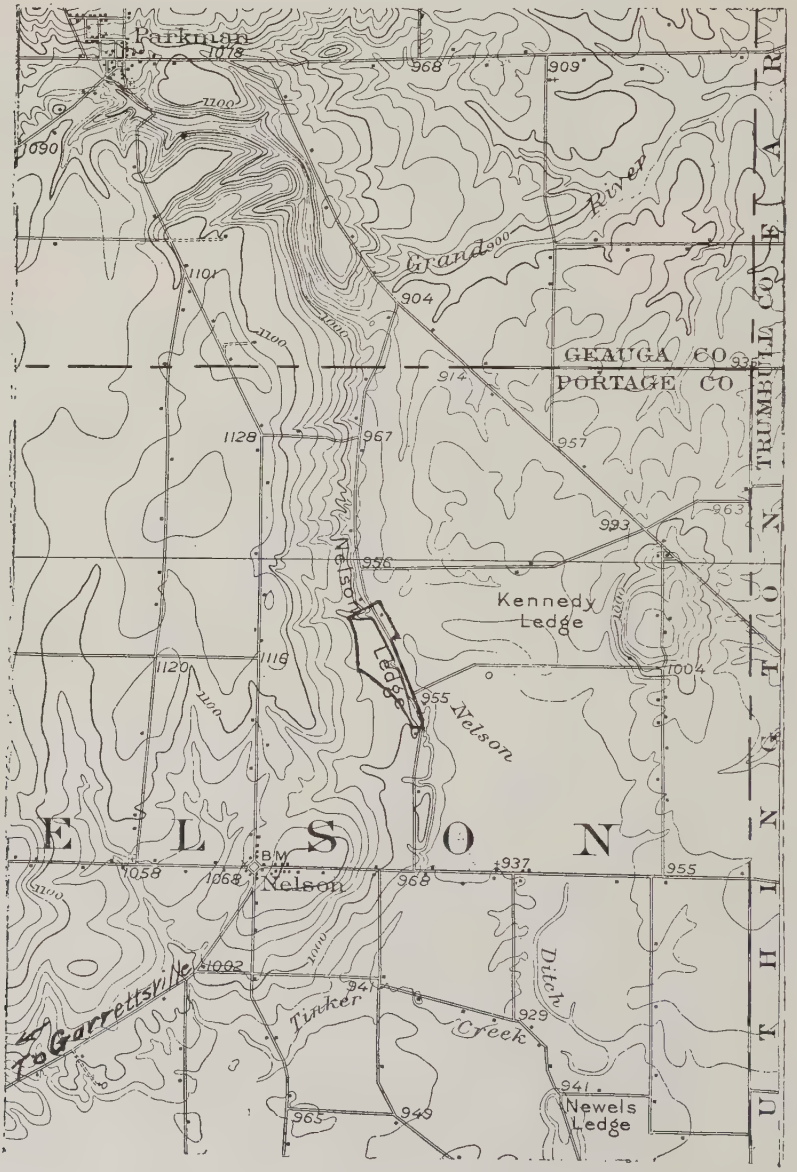


FIG. 2. Section of the Garrettsville quadrangle, showing Nelson Ledge State Park.

an outlier of the Sharon Conglomerate and stands well above the surrounding drift-covered plain.

The accompanying topographic map, a portion of the Garrettsville quadrangle, shows a broad, nearly flat plain lying between Nelson and Kennedy ledges. It is probable that in preglacial time a stream of considerable size occupied this valley. Its present floor displays the characteristic, hummocky topography of the ground moraine. To the east of the town of Nelson and in the vicinity of Nelson Ledge there are broad expanses of marsh-land. Nelson Ledge, a long erosional cliff, bounds the upland on the east and forms a nearly vertical wall for a distance of about 150 feet from the road which parallels its base. The upland to the west of the ledge has an average altitude of about 1,100 to 1,120 feet above sea level, rising to the west. The upland appears to be fairly flat, the rise to the west being gradual. The relief is characteristic of a glacial topography, rolling, with knobs, hollows, flat expanses and marshes here and there. Both Nelson and Parkman are located on the upland at an elevation of about 1,160 feet above sea level. The ascent is rather steep from the lowland to the upland, a rise from an altitude of 900+ to 1,100+ feet, a distance of 200 to 250 feet.

STRATIGRAPHY.

The indurated rocks in Ohio are all of sedimentary origin and of Paleozoic age, ranging from Middle Ordovician to Permian. They have a total thickness of 5,400 to 5,800 feet and comprise limestone, dolomite, shale, sandstone and conglomerate, with beds of rock-salt and gypsum in the middle part of the section and beds of coal and fire-clay in the upper part. The Lower Ordovician and Upper Cambrian are not exposed in the State and they rest on the pre-Cambrian complex made up of metamorphic rocks such as those which appear from beneath the Paloozoic formations in Wisconsin, Minnesota and Canada. Over-lying, and in most places concealing the hard rocks of the northern two-thirds of the State, is a blanket of glacial drift, which in places reaches a thickness of several hundred feet.

In the vicinity of Nelson Ledge the exposed rock formations are sedimentary and were laid down in the Mississippian and Pennsylvanian periods. Glacial drift covers the bed rock in most places but appears to be absent or thin at the Ledge and

on the upland immediately to the west. Well-logs indicate that the thickness of the glacial drift in the pre-glacial valley to the east of the Ledge varies from 80 to 120 feet.

The Cuyahoga formation which lies beneath the Sharon Conglomerate at Nelson Ledge belongs to the Waverly Series, a group of formations laid down during the Mississippian period. It consists mainly of shale and is commonly known as the "Cuyahoga Shale" but it contains in addition to shale a considerable amount of sandstone. The upper five or more feet of black or grey Cuyahoga shale are exposed at Nelson Ledge, in Gold Hunter's Cave, located at the foot of Cascade Falls. The Sharon Conglomerate lies unconformably above it. According to Wilber Stout, State Geologist of Ohio, this formation is correlative with the conglomerate at Sharon, Pennsylvania and with the Olean around Olean, New York. Farther south in Ohio it is prominent at Cuyahoga Falls, at the quarries near Massillon, at Glass Rock in Perry County and is at its best in eastern Pike and western Jackson counties in southern Ohio, where its thickness is from 50 to more than 200 feet. It appears to be correlative with the Mansfield of western Kentucky and southern Indiana. The Sharon Conglomerate is well displayed at Nelson Ledge, where it is massive and the pebbles numerous. Some of them are as much as 2½ inches long and 1½ inches in diameter; as large as a hen's egg. In southern Ohio the largest pebbles, occasional ones, are as large as the fist. Usually pebbles the size of a hen's egg are rather uncommon, most of the material being fairly fine. The great majority of pebbles range from one-half to three-quarters of an inch in size at Nelson Ledge. The matrix of the conglomerate is a coarse grained sandstone or grit, in which the pebbles are embedded. Where freshly broken, the sandstone is buff or red in color. The weathered surface is dark brown and where thoroughly oxidized, a bright red color. The conglomerate shows the effects of differential weathering, those beds offering less resistance to weathering forming hollows, and those of greater resistance, forming ridges. In places the pebbles are less numerous and the beds are mainly coarse sand. At Kennedy Ledge, to the east of Nelson Ledge, the conglomerate contains fewer pebbles and they are smaller, on the average. This is evidence that within short distances the nature of the formation changes considerably. Everywhere it shows beautiful cross-bedding,

bottomset, foreset and topset beds being common. Lamb[1] believes the Sharon Conglomerate is a stream deposit because of its position, constitution and structure. The pebbles are nearly all white, vein-quartz, occasional ones being rose-quartz or jasper. They are, without exception, well water-worn. The fact that they are all crystalline quartz, such as is found in igneous or coarsely crystalline rocks would indicate that they came from distant sources and not from Ohio or its neighboring states. The nearest coarsely crystalline rocks from which they could have been derived, were, during the Pennsylvanian period, located in the Canadian Shield to the north or the continent of Appalachia to the east. Studies made by geologists[2] indicate that the Sharon Conglomerate was laid down in troughs in the old Mississippian floor. It appears to be of marine origin, laid down in what are in some instances, broad valleys. The material apparently filled these valleys with thicknesses of from 100 to 200 feet of conglomerate. The Sharon coal, commonly known as the number 1 coal, was laid down above it. The older authorities attributed the pebbles to quartz veins in old Appalachia, but Hyde and Stout[2] tracing the streams through the short distance they are exposed along the outcrop, have the idea that they came from the northwest, from the southern part of the Canadian Shield. However the question is not a settled one and requires more work in the field for its solution.

The irregular, sharp contact of the Sharon Conglomerate with the Cuyahoga shale can be seen in Gold Hunter's Cave. Here the conglomerate appears to fill hollows on the undulating, eroded surface of the Cuyahoga. A careful study of the base of the Sharon Conglomerate, which constitutes the roof of the cave, reveals in places, pieces of flagstone, shale and cobble stones derived from the Cuyahoga, some angular, some rounded and flat and well worn, several inches thick and more than a foot long, lying in all directions and mixed with sand and pebbles.

The Sharon Conglomerate is reported to be 75 feet thick by Lamb[3] at Nelson Ledge. The writer measured its thickness at Cascade Falls with a tape and found it to be 45 feet. At the

[1]Lamb, G. F. Journal of Geology, Vol. 19, pp. 104–109, 1911.
[2]Hyde, J. E., Stout, W. Personal Communication from Stout.
[3]Lamb, G. F. Idem 1, p. 106.

Devil's Den a thickness of 49 feet was obtained. Prosser[4] reports a thickness of 150 feet based on barometer readings secured at the base of the conglomerate at Nelson Ledge and its highest outcrop on the highway east of the town of Nelson. The thickness varies because of two factors, erosion and the irregularity of the surface upon which it lies.

Economically, the Sharon Conglomerate is used in the manufacture of silica brick. The first silica bricks manufactured in the United States were made from the Sharon Conglomerate near Akron about 1875. Bricks of similar character are being made by the Niles Fire Brick Company of Niles, Ohio, the Ohio Quartz Products Company, Jackson, Ohio and the Portsmouth Refractories Company at Portsmouth, Ohio. Another company utilizing the conglomerate for refractory material is operating at Newels Ledge about three miles south of Nelson Ledge. The sized pebbles are also used extensively in water filtration plants and the fine material for sand blasting and foundry purposes.

GEOLOGICAL HISTORY[5].

For the benefit of those not familiar with the geological history of Ohio, a brief summary is included here Nothing is known of the rocks which underlie the Paleozoic strata of Ohio and little is known of the pre-Cambrian history. During the Paleozoic era the sea advanced and retreated over Ohio and sedimentary formations were laid down estimated to be over a mile thick. In Silurian time the sea became shallow and parts of it became lagoons, from which evaporation was rapid and in which mineral matter was concentrated and deposited as thick beds of gypsum and rock salt. At the close of Silurian time the Cincinnati arch in western Ohio, eastern Indiana and central Kentucky was uplifted as a broad geanticline. Toward the close of the Paleozoic era the seas shallowed in Ohio and during the Mississippian period the Waverly series of formations were laid down. They include the Bedford shale, Berea sandstone, Sunbury shale, Cuyahoga and Logan formations. Above the Logan formation and not included in the Waverly group is the Maxville limestone. At the close of the Mississippian period the seas withdrew and a

[4]Prosser, C. S. Bulletin 15, Fourth Series, Ohio Geol. Survey, p. 292.
[5]Based on Columbus Folio, No. 197.

long period of erosion ensued. The Maxville and Logan formations, if they extended over northern Ohio were completely removed by erosion and valleys from 100 to 200 feet deep were carved in the Cuyahoga formation. The unconformity marking the contact between the Cuyahoga Shale and Sharon Conglomerate of the Pennsylvanian is one of the most widespread and represents a period of erosion during which hundreds of feet of material may have been removed. During the Pennsylvanian period, eastern Ohio lay nearly at sea level, being at times submerged and receiving thin marine deposits and at other times being land, covered with vast swamps in which flourished the plants whose remains formed beds of coal. These conditions continued well into the Permian period, when the sea finally disappeared, and has never returned. At the end of the Paleozoic era a vast area which had been sea was uplifted into the Appalachian Mountains. During the Mesozoic era the Appalachian region including Ohio was beveled by erosion. This peneplane has been removed by erosion and another developed during the Tertiary era. The latter is represented by the upland in eastern and southeastern Ohio at an altitude ranging from 1,200 to 1,300 feet. This erosion surface, called the Harrisburg peneplane[6], was uplifted and dissected in Tertiary time and another surface, called the Worthington peneplane[5], developed at an average altitude of 1,000 to 1,100 feet.

In the Quaternary era great sheets of ice formed continental glaciers and spread outward from centers of accumulation in Canada. Four or perhaps five ice sheets successively invaded the territory west of the Mississippi River and at least two of them, the third or Illinoian and the last or Wisconsin, entered Ohio. At the time of greatest extent the ice covered two-thirds of the State, on the southwestern corner reaching a little beyond the Ohio River. As the ice advanced it eroded the surface more or less, accentuating the relief in some places and obliterating it in others. It picked up and carried along a great quantity of stones, clay and sand, which was in part carried away by the streams as outwash and in part deposited by the melting ice. The mantle of glacial drift left by the ice is in places several hundreds of feet thick. In areas of slight relief it has formed an entirely new surface, which bears little

[6]Ver Steeg, Karl. Erosion Surfaces of Eastern Ohio, Pan-American Geologist, Vol. LV, March-April, 1931.

or no relation to the bed rock topography, for it filled and obliterated many of the pre-glacial valleys in the old surface. During each interglacial epoch as well as since the final disappearance of the ice, a new system of drainage was established on the new surface and more or less dissected it. The preglacial drainage of the Allegheny Plateau was northwestward to the Erie Plain, but as the ice margin retreated across the State from south to north, the drainage from the melting ice at first escaped freely to the south and dissected the surface sufficiently to determine the direction and character of the drainage of the present time. After the ice had left the high ground and its margin was receding down the northerly slope to and across the Erie Plain, the drainage no longer escaped freely southward but was ponded in a series of small lakes between the ice edge and the plateau. At first these lakes discharged southward through notches in the plateau, but as the ice melted back their levels were lowered and broadened out and united to form a series of lakes that preceded the present Lake Erie. The divide between the drainage to the Ohio and that to Lake Erie was in part newly established and in part uncovered nearly everywhere along or close to the edge of the plateau. The post-glacial streams have cut down to bed-rock and made gorges in it and at other places have partly cleared out the drift-filled old valleys.

It is probable that the valley to the east of Nelson Ledge was occupied in preglacial time by a tributary which flowed northward to join the old Ohio, a large preglacial stream which flowed through the broad valley leading from Youngstown, Niles and Warren and out through what is now the valley of the Grand River to the Lake Erie lowland. The drift-fill in the lowland to the east of Nelson Ledge is from 80 to 120 feet thick.

ORIGIN AND FEATURES OF NELSON LEDGE.

In the preliminary topics we have discussed the location, drainage, topography, geologic history and stratigraphy of the area. With this background it is possible to proceed with the discussion on the scenic features at Nelson Ledge.

One of the outstanding characteristics of the Sharon Conglomerate are the well-developed joints which break the rock into great blocks. They occur in systems having definite trends. At Nelson Ledge the writer made observations on the

direction of a large number of joints and found one system with a trend of N. 35°–40° W. Another system has a direction varying from N. 10° E. to N. 30° E. most of them being N. 20° E. These two systems are nearly parallel to the cliff and are the most important. Another well-developed system runs from N. 60° to 80° W., and a few joints were recorded at about N. 65° to 70° E. There are four systems of joints, two parallel to the cliff and two which meet the others at a high angle. Such systems of widely spaced joints would tend to break the Sharon Conglomerate into huge, angular blocks. The cause for the jointing is attributed to differential stresses produced by crustal movements in the past, shrinking and settling of sediments due to loss of water incorporated in them when laid down, and the weight of the superimposed beds laid down upon them.

The tendency is for an escarpment to recede as a result of erosion. The recession is more pronounced when a hard rock formation, very resistant to erosion is underlain by a softer material. The removal of the weaker substance, commonly shale, from beneath the harder formation, a process of undermining, is known to geologists as sapping. At Niagara Falls, a similar process accounts for the retreat of the falls. At Nelson Ledge the Sharon Conglomerate, a hard, siliceous rock, very resistant to weathering and erosion is underlain by the Cuyahoga shale, five or more feet of which are exposed in Gold Hunter's Cave located beneath Cascade Falls. Here the undermining process has produced a semi-circular cavern about 80 feet long and 35 feet wide. The chief agent of erosion is Cascade Creek; it is evident that the origin of the cave is directly related to the formation of the pothole at the base of the falls. The waters of Cascade Creek, falling a distance of about 50 feet now dashes on a large boulder which fell from the cliff above and at present partly blocks the entrance to the cave. Although this rock breaks the force of the water to some extent, during heavy rains a great volume of water whirls around in the cave and further undermines the cliff It is probable that the fall of the rock is recent and that most of the undermining took place prior to its fall. Nevertheless the process is quite active at present. From the back of the cave and midway, there is a stream of water which issues from an opening in the rock. One can hear the roar of falling water somewhere to the rear and not far from the opening.

The water is falling from above through an enlarged joint in the Sharon Conglomerate. Here we have another example of how the undermining process is accomplished. The softer shale is thus removed by the work of water flowing along enlarged joints. That this process is effective can be observed at the Devil's Den and in the narrow gorge or cleft immediately to the west of it. That the undermining process takes place to some extent by underground water flowing along joint planes is further suggested by the numerous hollows and sags on the upland to the west of the cliff. Here for several hundred feet back from the escarpment the upland has the appearance of an undermined area.

There is another point in the park where similar processes of erosion have produced a cave and a deep narrow gorge. A stream, Sylvan Creek, heads in a swamp to the west of the State Park area, and after flowing eastward to a point about 50 feet east of the park boundary, dashes over Sylvan Falls into a deep narrow channel. This gorge, about 50 feet deep, has been cut along the joint planes and has an angular, zig-zag form, the result of excavation along two joint systems which meet at an angle; one system has a northwest and the other a northeast trend. So narrow is the gorge that at a point just west of the Devil's Den it is little more than a cleft in the rock, in some places not more than two or three feet wide and standing at an angle of about 70 degrees. Similar features have been produced at the Dells of the Wisconsin at Kilbourn, as a result of streams following the joints in the Potsdam sandstone of upper Cambrian age. There the Wisconsin River and its smaller tributaries have followed the joints, forming post-glacial gorges, in some places extremely narrow and angular.

At the Devil's Den, Sylvan Creek has been very effective in undermining the conglomerate. As a result the rock has fallen in and been further removed by weathering and water action. One large block at the Devil's Den, which has been undermined, is tilted and has dropped down a distance of about three feet, forming a scarp; at other points in the park where undermining has allowed blocks to settle, scarps are present. In several instances two blocks have fallen so that the tops rest together while the bases are detached forming grottoes such as Hanging Wall Cave and Old Maid's Kitchen. There are also not infrequent caves formed by joints where

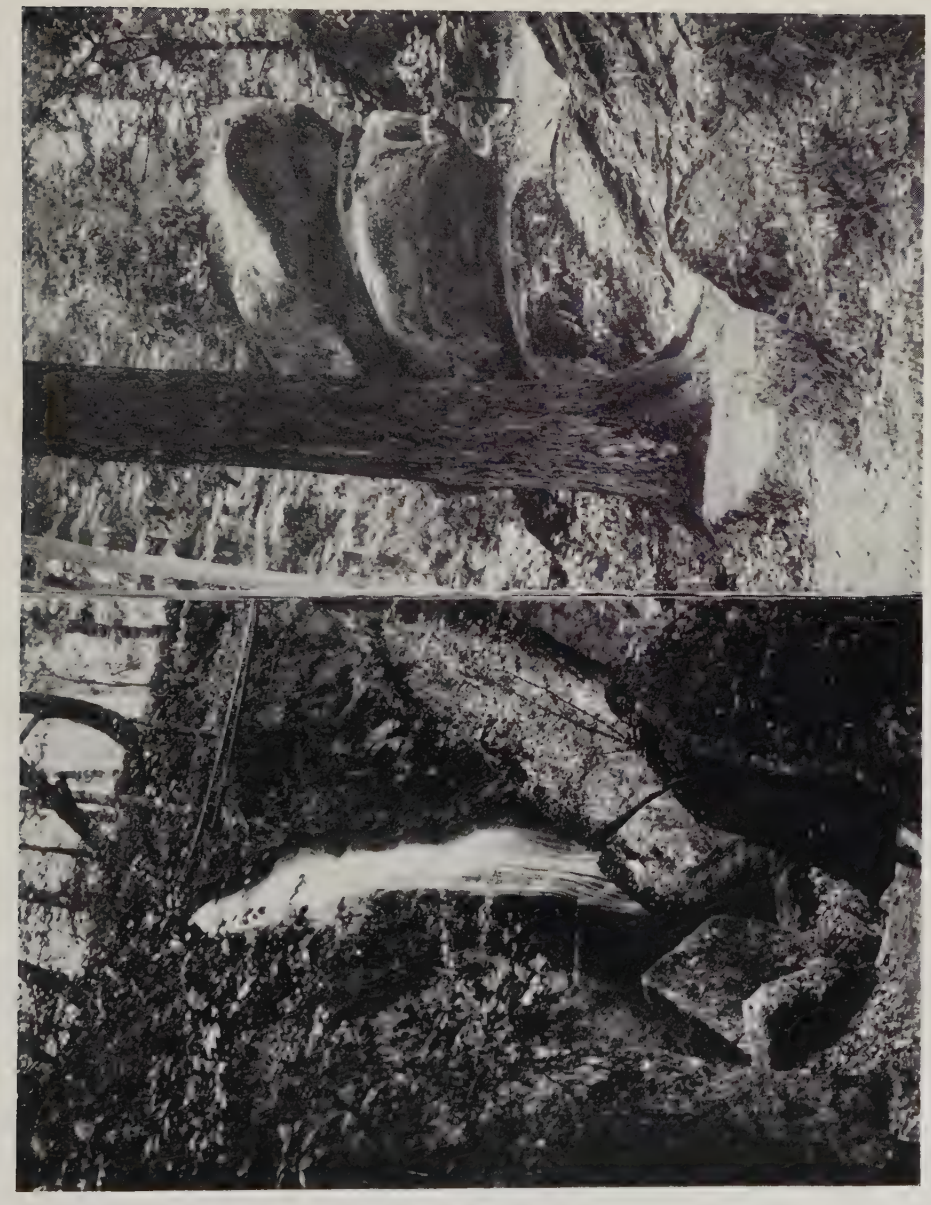


FIG. 3.
Cascade Falls.

FIG. 4.
View along the trail. Sharon conglomerate well displayed.

they are roofed over by the upper layers, an excellent example being Shelf Rock Corridor. In many cases the blocks are tilted away from the cliff, producing a wide crevice at the joint plane where the break occurred. To the east of the Devil's Den there is another grotto through which flows Sylvan Creek. It measures about 40 feet from end to end and is called the Devil's Ice Box because of the low temperatures which exist, even during the warmest days of summer. Here the creek has undermined the conglomerate and produced a cave. It requires no stretch of the imagination to picture the collapse of the roof and the tilting of the block, a process which doubtless has taken place many times in the past. It is quite apparent that the undermining process has been very effective along the creeks. The great boulders are much more numerous at Cascade Falls and along Sylvan Creek, east of the Devil's Ice Box. It is obvious that the undermining process is at present taking place far back from the cliff along Sylvan Creek. The greater effectiveness of the streams in the undermining process accounts for the greater number of detached blocks of conglomerate along them. The two systems of joints, which parallel or nearly parallel the ledge face or scarp, facilitate the breaking of the blocks from the ledge after the undermining process has accomplished its work. At some distance back from the cliff, possibly a few hundreds of feet, the water is finding a way of escape by draining downward through the joint planes in the conglomerate. It is probable that the joint planes have been much enlarged by weathering and undermining. The surface is quite hummocky with many shallow depressions reminding one of an undermined area.

The most picturesque localities in the park are at those places near the creeks where the undermining process has produced many isolated blocks of rock and deep, narrow gorges. The two most interesting spots from both scenic and scientific stand-points are at Cascade Falls and along Sylvan Creek from Sylvan Falls to Temple Rocks. The picturesque trails along which are found the glens, narrow gorges and grottoes, are marked off into three routes, which combined, measure more than a mile in length.

A common misconception by the layman concerning the processes which have operated to produce the fallen blocks of rock is that a great earthquake took place at some time during the past to produce the assemblage of huge boulders standing

at all possible angles. This is not correct, for as has been pointed out in the previous discussion, a slow process of undermining by weathering and erosion is the sole cause. Some day the roof of Gold Hunter's Cave will collapse. The downward movement might be a sudden one, the impact producing a small earthquake. Minor earthquakes occur occasionally in regions where caverns or underground passages are present in limestone areas. The collapse of the roof or the fall of masses of rock from above to the floor of a cave may be the cause. Small earthquakes have occurred in the vicinity of Niagara Falls, when great blocks of undermined limestone have fallen from the brink of the falls to the gorge below.

It has been suggested that a stream to the east of Nelson Ledge accomplished the undermining responsible for the great blocks of conglomerate which lie below the cliff. It is not necessary to account for them in that manner, for it is obvious that the processes of weathering and erosion by running water are very active at present in producing the features of the park. Furthermore it is impossible to account for the undermined areas back from the ledge face by the action of a stream to the east.

A process not given much consideration so far, is that of weathering. The joints allow the ready movement of water downward from above. This water which carries oxygen and carbon dioxide, and direct contact with the air itself, accomplish changes. As a result the rock undergoes a process of chemical disintegration. Mechanical weathering takes place when the water, absorbed by the rock and filling the cracks, freezes. The expansion causes the rock to break, repeated freezing and thawing producing mechanical disintegration. By chemical and mechanical processes of weathering the joints are gradually enlarged. In some cases the debris which has fallen into the crevices from the walls above, has nearly filled them. It is probable that the hollows on the upland, back from the face of the ledge, are due mainly to the enlargement of the joints by weathering. The Sharon Conglomerate weathers differentially, the more resistant beds standing out conspicuously. One occasionally sees numerous, small, nearly circular, shallow hollows in the conglomerate where it has been exposed to weathering. The Sharon Conglomerate has a tendency to weather with rounded instead of sharply angular outcrops.

Another weathering process which has aided in rock disintegration is the result of plant growth. There are a number of large trees in the park whose roots occupy the narrow spaces or joints between the blocks of conglomerate, gradually wedging them apart. One wonders how the trees can live when their roots extend down into what appears to be barren rock. Such trees are found at a number of places in the glens such as Lundy Lane and others. In some cases the trees cling to the vertical walls of the conglomerate. Mosses, ferns, and lichens where there is sufficient moisture, cover the walls with a mass of growth. Because of the dense foliage which shades the ledge the evaporation is small, and these plants flourish in the cool, damp glens. They absorb moisture and further aid the process of weathering.

One sees in Gold Hunter's Cave and in other parts of the park, a brilliant, yellow material commonly known as ochre or limonite ($Fe_20_3.3H_20$). In the cave it is being precipitated from the waters of the spring which issues from the back wall of the cave. The spring doubtless obtained its iron from the Sharon Conglomerate through which it has flowed or percolated. Wherever the water issues from the conglomerate and stands for any length of time, an iridiscent scum, resembling oil forms on the surface. This scum is produced by oxidation at the surface of the water, where the iron in solution comes in contact with the oxygen in the air. Hanging from the roof of Gold Hunter's Cave are numerous, short, rounded stalactites of limonite. It is possible that the ochre results from the weathering of iron pyrite present in the Sharon Conglomerate. The water from the conglomerate, although it contains a small percentage of iron in solution, is soft, and contains little carbonate of lime and other impurities which require soap for softening.

Bacteriology.

A new and reset edition of a standard text-book on bacteriology. The older editions were among the best of their kind, and the new edition seems to live up to the high standard previously set. New material in this edition includes thorough discussions of the bacteriophage, of the role of bacteria in the arts and industries, and of the practical applications of this subject especially in regard to milk, butter and water. Other chapters have been entirely rewritten.

The same clear style and thorough treatment that characterized the older editions are apparent in this, and it will undoubtedly continue to receive the same enthusiastic welcome which it has enjoyed in the past.—S.

Elementary Bacteriology, by Joseph E. Greaves and Ethelyn O. Greaves. 535 pp., 12 mo. Philadelphia and London, W. B. Saunders Co., 1932. $3.50.

A NEW TRIGONOCARPUS FROM OHIO.

WILLARD BERRY,
Ohio State University.

In the collections of the Geological Museum of the Ohio State University there is the cast of a fossil seed that appears to be new to science. This seed is from the Upper Carboniferous (Pennsylvanian) at Steece, Lawrence County, Ohio. It was presented by E. L. Lambert through E. B. Willard and is number 10,429 in the collections. No additional information is definitely known about its history. However, Lambert was mine superintendent for Willard and they were mining the Vanport limestone at Steece. There the Vanport limestone is overlain by a sandstone. (The entrance of the mine is still open but the rest is flooded.) It is probable that the seed is from this sandstone above the Vanport limestone and below the No. 5 coal. The sandstone is the Kittanning sandstone of the Pennsylvanian Survey.

This seed-cast is rather unusual as it is much larger than most and the ribs are double, although only three in number. I have referred it to the genus *Trigonocarpus* although it may represent a species of *Radiospermum*. The presence of an opening in the base might be interpreted as where the pith entered the seed, in which case it should be referred to *Radiospermum*. However, investigation on one side of the seed where it was damaged seems to indicate lack of internal structure, therefore I have referred it to *Trigonocarpus*.

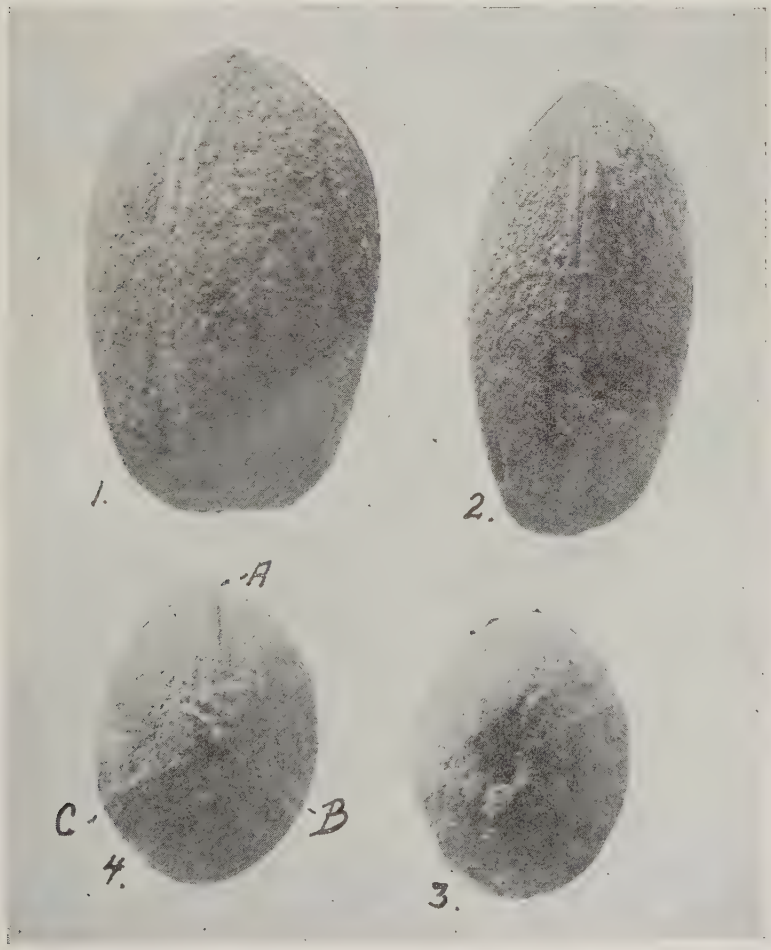
The cast is of sand with abundant ferruginous cement. The surface is composed mainly of the cement.

As far as I can ascertain it is a new species and cannot be referred to any described form. The nearest described form is *Radiospermum ovatum* (Lindley and Hutton) as described and figured by Arber, although my seed lacks structure. It may be described as follows:

Trigonocarpus steecensis W. Berry n. sp.

(Figures 1, 2, 3 and 4.)

From the side, elongate-ovoid in form, slightly broader towards the apical end. In cross section elliptical. Surface crossed from apical end to base by three prominent double ribs—A, B and C. Double rib A is composed of two ridges each about 1 mm. broad separated by a narrow groove averaging 0.5 mm. wide, from which towards the apical



Trigonocarpus steencensis W. Berry, n. sp.

Fig. 1. Side view showing rib B.
Fig. 2. Edge view showing rib A.
Fig. 3. Basal view.
Fig. 4. Apical view, double ribs A, B, C, labeled. About natural size.

end rises a narrow fin or wing, about 0.5 mm. wide and broken off elsewhere. The entire length of the groove is occupied by what appears to be the continued base of this wing. Double rib B is about 130 degrees from A, and C about 90 degrees from B. The double ribs are all alike, although the width of them may vary slightly. These double ribs rise at the base of the cast, though all but B are very faint at the base, and tranverse the surface towards the apical end, where they are lost as the apical end is not entirely preserved. About 43 degrees on either side of A is a shallow groove, the one between A and B being the most pronounced. This groove is about 2 mm. broad and 0.75 mm. deep and runs from near the base to within 2 cm. of the apical end. The groove between A and C is much less clearly marked and is slightly wider, otherwise like the first one.

Balance of the surface shows the rounded sand grains of the cast.

Apical end more or less destroyed, enough preserved to show that the double ribs came almost to it, there is just a faint suggestion that the double ribs enclosed a small "pollen chamber."

Basal end shows the three double ribs coming in towards the center, which is an irregular oval opening about 4 mm. by 2 mm. This hole penetrates about 4 mm. into the cast.

Length, 6.5 mm.; breadth, 4.4 mm.; depth, 3.5 mm.

Living Machinery.

The preparation and radio-broadcasting of a series of talks on biological principles lead to their subsequent collection and publication in book form. The result is a pleasing collection of essays covering in popular form a wide variety of subjects, all centering on biology and its modern applications. The author states that the book is designed to raise questions rather than to answer them, and it must be said that it does just this. The essays are in effect short introductions to the various subjects. The reader is apt to find that just as he thinks the author is warming up to his subject, the essay abruptly closes. However, the arousing of a desire to know more about the subjects treated is one of the best features of the book.

A few poor analogies are used, such as comparing the variability of heredity with the words possible from combinations of letters of the alphabet, in which it is forgotten that letters may be missing from words, but that one or another of each set of allelomorphs must be present in each organism of a species. An occasional loose statement is found, such as the use of "morons" where obviously "cretins" was meant. Teleological statements appear freely. However, these are minor defects, and the book will provide entertaining reading not only for the layman but for the trained biologist as well. Especially good are the chapters on foods, and the one on parasitism.—L. H. S.

The Machines We Are, by ROBERT T. HANCE. xvi+382 pp., New York, Thomas Y. Crowell Co., 1932. $3.00.

STARCH SYNTHESIS IN THE VARIEGATED LEAVES OF PELARGONIUM.[1]

A. G. CHAPMAN AND W. H. CAMP.

INTRODUCTION.

Under natural conditions, the non-green portions of most variegated leaves do not synthesize starch. It has, however, been known for some time that the non-green portions of many leaves could synthesize starch if artificially supplied with glucose.

In the green leaf, the more important underlying conditions known to affect starch synthesis are: the concentration of soluble carbohydrates; the type and distribution of plastids; the activity of certain enzymes, particularly the carbohydrases; and the hydrogen-ion concentration of the cell contents.

Böhm (1883) was probably among the first to show that green leaves would synthesize starch in the chloroplasts if floated on a sugar solution in the dark. Spoehr (1926) mentions similar investigations by Meyer (1886), and others. Saposchnikoff (1889) and Borkorny (1897) also showed that starch synthesis would occur in starch-free green leaves of many species if floated on solutions of soluble carbohydrates in the dark. Miller (1931) reports that Böhm (1883), Schimper (1885), and Meyer (1886) found that starch formation occurred in chloroplasts and leucoplasts only when the solution of sugar had reached a certain concentration. Winkler (1898) concluded that when the concentration of glucose or sucrose is sufficiently high, all chloroplasts and leucoplasts, with but few exceptions, form starch. He found that the lowest concentration of sucrose which induced starch formation in most cases was 0.02 percent, the optimum 10 percent; above this the starch decreased until in a 30 percent solution of sucrose no starch was produced. Spoehr (1926) concluded that the concentration of glucose necessary for starch formation varies widely for different plants. Lundegardh (1914) claimed that the transformation of sugar to starch in cells is very complicated, and that the process depends not only upon the

[1]Papers from the Department of Botany, The Ohio State University, No. 300.

concentration of sugar in the cytoplasm, but also upon the amount of an enzyme, the concentration of which is controlled by unknown factors. Spoehr (1926), pointed out that various workers have found that plants form starch in the dark when floated on solutions of not only glucose, fructose, galactose, mannose, sucrose, and maltose, but also of such alcohols as mannitol, ducitol, erythritol, and glycerol. According to Winkler (1898), formaldehyde and an extract from natural humus may also be used.

FIG. 1. *Pelargonium* plants from the clon culture used in the experiments.

A number of investigators have studied the ability of various plants to synthesize starch in the non-green portions of their leaves, and also certain of the factors which normally inhibit its formation. Winkler (1898), after unsuccessful attempts to induce starch synthesis in the white portions of the leaves of *Pandanus Veitchii*, found there were no plastids present. Hein (1926) in a review of the subject quotes Woods (1899) as believing that in *Pelargonium* and in many other cases of variegated leaves, the chlorophyll is destroyed by oxydizing enzymes, the oxidases and peroxidases, which are normally present in all green plants and under certain conditions may be produced in abnormally large quantities. He also states that Baur (1904) found that the plastids in the white cells of *Pelargonium* uniformly contain little or no chlorophyll and are smaller than the plastids in the green cells, and that

Küster (1919) concluded that the plastids in the non-green areas of *Pelargonium* are incompletely developed or have become bleached and degenerate, possibly through agencies inside the cells.

Maige (1924), studying the effect of temperature on starch formation in various leaves, found within certain limits, a correlation between the two. Henrici (1921) showed that the minimum temperature and light intensity necessary for photosynthesis are lower than those required for starch formation. Gillis (1923) thought that the formation of starch from sugar in variegated leaves depends to a certain extent on light.

The work done by the present writers was undertaken as a further study of the factors which inhibit starch formation in non-green leaf tissue under normal greenhouse conditions, and of the factors which affect the rate of starch formation when carbohydrates are supplied.

In the preliminary work, various species of variegated-leaved plants were used. The present report, however, is found in studies of the variegated geranium (*Pelargonium hortorum* var. *Mme. Salleroi*).

The writers wish to acknowledge the help of Dr. H. F. Thut of the Alabama Polytechnic Institute, who assisted in the preliminary part of the investigation.

SUGAR CONCENTRATION OF SUBSTRATE.

In this portion of the investigation, the material consisted of carefully selected *Pelargonium* leaves obtained from plants of a clon culture. (Fig. 1).

METHODS.—Mature, but active leaves from representative plants were removed with a sharp razor. The cut ends of the petioles were immediately immersed in freshly prepared glucose solutions of 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7 molecular concentration.[2] A sufficient number of albino as well as variegated leaves were available for the study. Two series were made, one being placed in the dark, the other in the light, the temperature and atmospheric humidity being nearly equal in both situations.

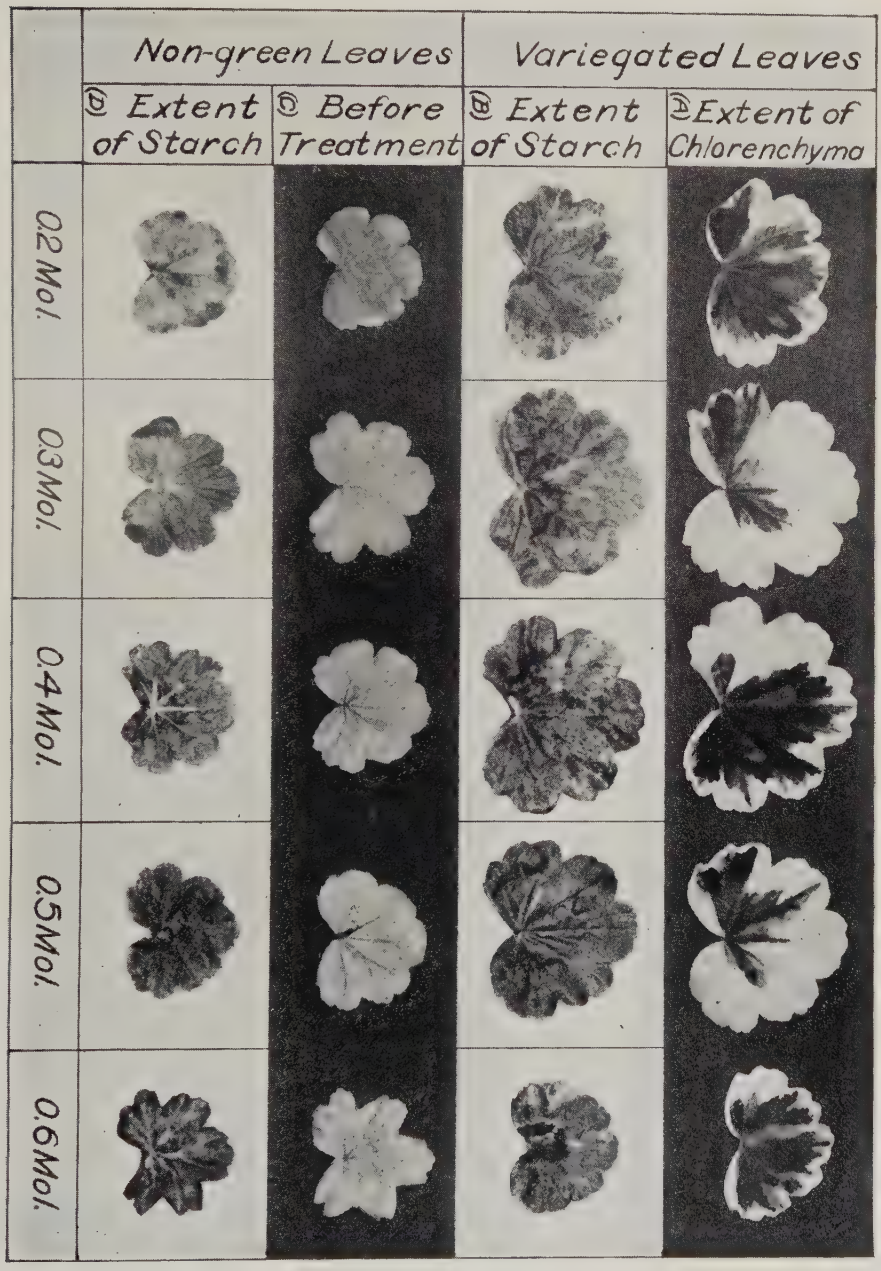
After fifteen hours, the chlorophyll was removed from the leaves by means of ethyl alcohol and starch tests made by the usual iodine method.

[2]All glucose solutions were weight molecular from C. P. material.

RESULTS.—The following results were obtained in both the variegated and albino leaves. A trace of starch was present in the leaves which were in the 0.2 molecular solutions. In the higher concentrations, the amount of starch in the leaves increased proportionately with the concentration of the glucose up to the 0.5 molecular solution. In the 0.6 molecular solution a slight decrease was noted, and only a trace of starch appeared in the 0.7 molecular solution. Slight effects of plasmyolysis were observed in a few of the leaves in the 0.6 molecular solutions; and wherever this condition was found, a noticeable decrease in the starch was observed. The small quantity of starch in the 0.7 molecular concentration probably was due to the conditions accompanying plasmolysis which was most severe in the albino portions. Non-green portions of the leaves in 0.3, 0.4, 0.5 and 0.6 molecular concentrations, except where noted for the 0.6 molecular solution, became dark violet in color on the application of the iodine solution. No great difference could be observed between the green and non-green portions of the leaves after testing; the transition line between the two portions disappeared because of the uniform distribution of the starch. (Fig. 2.)

No noticeable difference occurred in the amount of starch synthesized by leaves in the dark or in the light.

DISCUSSION.—While Winkler (1898) and others selected glucose and sucrose as the two most desirable materials for synthesizing starch in leaf tissues, they employed almost exclusively a 10 percent solution of sucrose. Winkler does not state the time required for starch formation in starch-free *Pelargonium* leaves; but for other species, the time varied from one day to three weeks. To keep the floating leaf parts as free as possible from bacteria and fungous growth, he occasionally transferred the material to fresh sugar solutions which were treated with a sufficient amount of phosphoric acid for sterilization. In many cases, there was a continuous increase of starch in the leaf tissue over a period of two to three days. This delay and comparatively long period of gradual increase might have been closely correlated with the rate of hydrolysis of sucrose in the acid solution. It has been well established by Weevers (1924) and others that starch is not synthesized directly from sucrose. It is therefore the opinion of the writers that in the earlier work, where sucrose was used as a substrate,



Series of leaves of *Pelargonium* showing the amount of starch synthesized in 15 hours when the cut petioles are immersed in varying molecular concentrations of glucose. Rows A and B are from variegated leaves before and after treatment. Rows C and D are from albino leaves.

that it was not sucrose that was used by the plant in starch synthesis but its hydrolytic products.[3]

It was known long before the investigations of Winkler (1898) that light is not necessary for starch synthesis. Yet Winkler thought that there might be an indirect influence of light upon the starch building process, such as, "a promoting of chloroplasts" and "a retarding of leucoplasts." Miller also mentions that "The formation of starch might be influenced by light in an entirely different manner from that influencing the process of photosynthesis."

The writers' results obtained from *Pelargonium* leaves in both daylight and complete darkness show no observable difference in the quantity of starch synthesized in the non-green portion. At least for this species, any indirect beneficial or deleterious effects of light, due either to intensity or quality, are probably insignificant or lie outside the range of intensity and quality of light experienced under greenhouse conditions.

SUGAR DETERMINATIONS.

As the preliminary work showed that starch synthesis would occur in the non-green portions of *Pelargonium* leaves when glucose was supplied, the following study was made to ascertain the relative amounts of sugar normally present in the several parts of the leaf.

Methods.—Total sugar determinations were made, according to the Shaffer-Hartman method, on duplicate samples of both green and non-green portions of the same leaves. The samples were collected shortly before noon on a clear day and transferred at once to 80 percent ethyl alcohol which was soon brought to the boiling point to prevent further enzyme action. Five-tenths of a gram of calcium carbonate was also added to neutralize any acids present. The amounts of total sugars were calculated from the standard Munson-Walker tables.

As it has been established that starch may be synthesized from several of the soluble carbohydrates or their hydrolitic products, no attempt was made to differentiate between the reducing and non-reducing sugars, the results being expressed as total sugars.

Results.—Expressed in the percentage of the fresh weight,

[3]It may be noted that the writers were able to obtain starch synthesis when fructose was used as a substrate.

samples from the green portion contained 0.36% total sugars, while the albino portions contained only 0.18% total sugars.

Discussion.—Analyses by the writers have shown that the total sugar content of the green tissue at mid-day was approximately twice that of the non-green part. It is generally known that there is a point of sugar-starch equilibrium above which starch formation exceeds starch hydrolysis, and that this point of equilibrium may shift with certain internal factors. The fact that starch synthesis is induced by artificially supplying glucose, leads the writers to believe that the sugar concentration and its relation to the sugar-starch equilibrium is an important factor in the lack of starch formation in the non-green leaf portions of *Pelargonium*.

FLUCTUATION IN HYDROGEN-ION CONCENTRATION.

The well-known effect of hydrogen-ion concentration on many physiological reactions prompted the writers to make a study of this factor in relation to the problem of starch synthesis. Determinations of the hydrogen-ion concentrations were made to show the changes in pH over a period of twenty-four hours.

Methods.—In the study of the pH fluctuation over a twenty-four hour period, pots in which the plants were growing were sunk two-thirds of their depth in sand. The plants and sand were watered to insure a sufficient water supply during the course of the experiment.

Starting at 12 noon on May 26, 1931 samples of the green and non-green portions of the leaves were taken every three hours until noon the next day. Thirty-six plants, derived from a clon culture, were used. During the entire period of the experiment the sky was clear. The samples were obtained by separating the green and non-green portions of representative leaves with scissors until enough material was obtained to make a determination. Twenty-five leaves were used for each determination.

The separate samples from the two parts of the leaves were placed in one-inch, rubber-stoppered test tubes and immersed in a bath at —20 C., where they were quickly frozen. After ten minutes the samples were thawed and the juice expressed by means of a power press at a standard pressure of 2500 pounds per square inch. It was only by this method that a sufficient quantity of extract could be obtained to make a

determination. The quinhydrone potentiometer was used to find the hydrogen-ion concentration of the expressed juice. Since none of the pH values found closely approached the pH of 7.0, there was probably no decomposition of the quinhydrone sufficient to produce anomalous results.

Determinations of fluctuations in pH over a 24-hour period in the variegated coleus (*Coleus Blumeii*) were made at the same

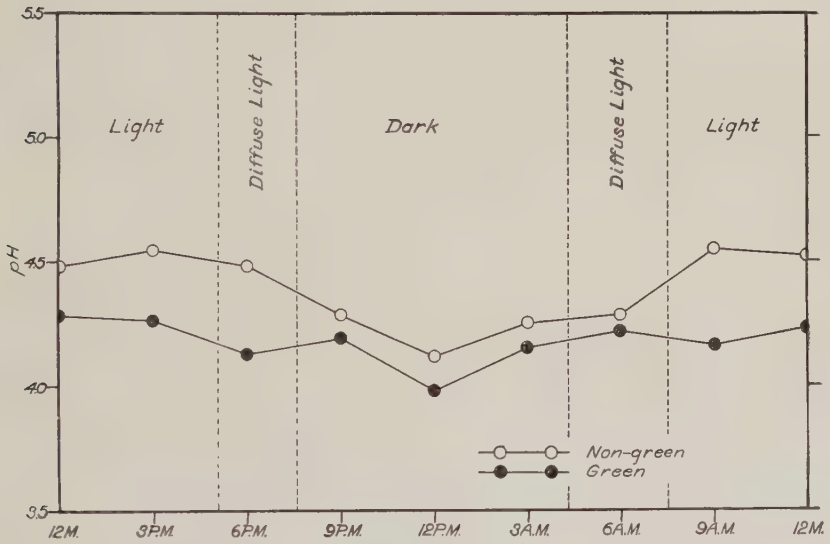


FIG. 3. Comparison of the fluctuations of the pH values in the green and non-green portions of the variegated leaves of *Pelargonium* over a 24-hour period.

time. Determinations of the relative pH of the margins and central portions of the non-variegated leaves of cabbage (*Brassica* sp.) were also made.

RESULTS.—Figure 3 shows the fluctuation in pH in the green and non-green portions of the leaves during a twenty-four hour period. It is evident that although fluctuations occur, the non-green portion of the leaves was consistently higher in pH than the green portion.

In the study of pH fluctuation in the variegated coleus it was found that the non-green inner portion of the leaf varied between 5.10 and 5.95, while in the outer green portion the pH varied between 5.85 and 6.15.

The cabbage without variegated leaves, showed a pH

value of 5.85 at the margin of the leaf and a pH value of 5.72 in the central portion.

Discussion.—It is clear from the above results that the outer (non-green) portions of *Pelargonium* leaves are consistently higher in pH than the inner (green) portions. Studies of the variegated-leaved coleus, in which the position of the green and non-green areas is the reverse of those of *Pelargonium*, as well as of the entirely green leaves of cabbage, gave similar results. Freeland (1931) also found that the leaf margins of *Bryophyllum calycinum* and *B. crenatum* had a higher pH value than the central portion. These various results led the writers to believe that in the species examined the decreasing gradient of pH from the leaf margin to the center is not so much correlated with the green or non-green tissues as with their position in the leaf.

HYDROGEN-ION CONCENTRATION OF THE SUBSTRATE.

In the previous experiments on the fluctuation in H-ion concentration, the writers found a difference between the green and non-green portions of *Pelargonium* leaves. It was thought that this difference might influence the point of sugar-starch equilibrium. Therefore, a study was made to determine, if possible, whether a difference in the H-ion concentration of the substrate on which the leaves were floated would influence the formation of starch in the leaf.

Methods.—Using oxalic acid, the writers prepared two series of non-buffered solutions having pH values of 2.7, 3.1, 3.3, 3.6, 3.8, 4.0, 4.2, 4.4, 4.7, 4.9, 5.2 and 6.1. Enough glucose was added to the solutions of one series to give a molecular concentration of 0.45. Both variegated and non-green leaves were cut into strips and floated on the solutions, some with the upper surface and others with the lower surface exposed to the air, being sure that the cut margins were in contact with the solution. The leaf portions in the series containing no sugar were exposed to the light from a 200 watt, concentrated filament bulb at a distance of two feet, for fifteen hours before being tested for starch by the usual iodine method. The second series, containing sugar, was placed in diffuse light, other conditions remaining approximately the same as those of the first series.

The pH values of the solutions were re-determined at the end of fifteen hours.

RESULTS.—Table I shows the results obtained from the above experiment. The numbers used indicate the relative amounts of starch present in the tissues at the various H-ion concentrations. The number "1" indicates a trace of starch; "6" indicates an abundance of starch.

It may be noted from the table that starch was synthesized throughout the entire range in acidity in both the green and non-green tissues of the leaf portions floated on glucose in diffuse light. In the non-green portions, the starch was most abundant near the veins and cut edges. The maximum starch formation in the non-green portions occurred at pH 4.4, while the maximum amount in the green portions occurred in the solutions having a pH of 3.8—4.0.

TABLE I.

Table indicating the relative amounts of starch found in variegated leaf portions of *Pelargonium* floated on oxalic acid solutions of different pH values; one series in diffuse light containing glucose at a 0.45 molecular concentration, the other in continuous bright light, but containing no glucose. Further explanations may be found in the text.

pH		2.7	3.1	3.3	3.6	3.8	4.0	4.2	4.4	4.7	4.9	5.2	6.1
Series with Glucose	Non-green	1	1	2	3	3	4	4	5	4	4	3	3
	Green	4	4	4	5	6	6	5	5	4	4	3	3
Series without Glucose	Non-green												
	Green	5	5	6	6	6	6	6	6	6	6	5	4

In the leaf portions of the series exposed to continuous light but having no additional glucose in the solutions, it was found that the green portions of the leaves contained abundant starch throughout almost the entire range, although starch was completely absent in the non-green portions.

Examination with the microscope revealed that while the starch grains exhibited the ordinary violet color associated with the iodine reaction, the vacuoles of the mesophyll cells of the leaves in the continuous light on the sugar-free solutions, contained a red staining substance, probably a dextrin, throughout the entire range of the experiment. The color was most intense at the ends of the series being less intense from pH 3.8 to 4.4. Neither starch nor dextrin could be detected in the non-green cells of the same leaves.

In the series floated on the sugar solutions in diffuse light, dextrin was detected in the green cells of the leaves from pH 2.7 to 3.6, and again from 4.9 to 6.0, practically no red color being detected from pH 3.8 to 4.7. In the non-green leaf portions, only a slight red color could be detected at the lower pH values, the color becoming more evident in the higher values, within the same range as that for the green portions.

At the end of the experiment it was found that little change had taken place in the pH values in either series up to 3.8, but beyond this point there was a gradual increase in the pH value of all solutions, none of them being higher than 6.2.

Discussion.—The writers are aware that they can not state the effectiveness of oxalic acid in regulating the H-ion concentration of the cell contents of tissues floated on a solution of this acid; yet it is evident that in those leaves floated on sugar solutions, the maximum starch synthesis occurred in those having a pH value near the averages for the two portions of the leaf under greenhouse conditions, that is, pH 4.4 for the non-green tissue and pH 4.0 for the green.

It is found that some form of dextrin is an intermediate stage between the monosaccharides and starch in *Pelargonium*, although between pH 3.6 and 4.9 where the dextrin was found to be low or absent, this transition stage may be passed through more quickly than at lower or higher pH values.

It is possible that the acid conditions of the various solutions might so change the permeability of the cell membranes that at the different pH values a greater or less amount of soluble carbohydrate, if available, might diffuse into the tissues and be used in starch synthesis. This possibility, however, is thought to be small in this particular experiment, for although the green portions of the leaves in the series in continuous light were gorged with starch and dextrin, at no pH value had sufficient soluble carbohydrates diffused from a green cell into an adjacent non-green cell to bring about starch synthesis.

It is suggested that the carbohydrases in the green cells are sufficiently active to almost immediately change any photosynthetic product into an insoluble form, particularly within the pH range of the normal green tissue.

Whatever the effectiveness of the oxalic acid may be in regulating the acidity of the cell contents, it is quite evident that the two tissues synthesize starch most abundantly in

a range of pH values, the point of maximum activity for the non-green being somewhat higher than that in the green.

TEMPERATURE EFFECTS.

Since the greatest amount of starch in the non-green parts was found in leaves treated in the 0.5 molecular solutions, this concentration was selected for a study of the effect of temperature on starch synthesis.

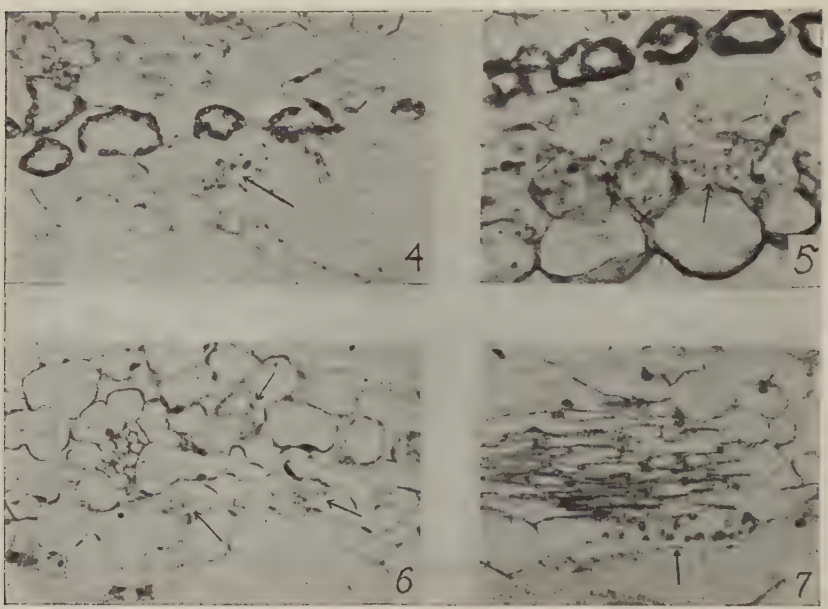
METHODS.—A series of 0.5 molecular glucose solutions, containing variegated leaves, was distributed in constant temperature chambers at 4°, 8°, 12°, 15°, 20°, 25°, 30°, 35°, 38°, 40°, 48°, and 50° C. At 38°, and above, large beakers were placed over the leaves to reduce transpiration. Starch tests were made at the end of fifteen hours. Microscopic examinations were made to detect any small quantities of starch present.

RESULTS.—A few of the leaves from the 4° C., chamber revealed a trace of starch in the cells of the albino mesophyll. Most of the leaves from the 8° C. chamber had a trace of starch, and all of the leaves from the 12° C., chamber showed a small quantity, yet a decided increase over the preceding. A very noticeable, steady increase of starch with increase of temperature appeared until a maximum was reached at 25° to 38° C. At these temperatures, the non-green portions were gorged with starch. Above 38° C., the amount of starch synthesized decreased until only a trace was found in a small number of leaves at 50° C.

DISCUSSION.—It has been recognized since the work of Böhm (1883) that temperature has an appreciable effect upon the amount of starch synthesized in leaf parts floated on sugar solutions. Winkler (1898) reported starch formation in treated leaf tissues of various species over a range of temperatures from 1° to 45° C., stating that the optimum range for most plants lay between 10° and 20° C. In the temperatures above 20° C., he found no further increase in starch.

Using a 0.5 molecular solution of glucose, the writers observed that the greatest yield of starch in the white parts of *Pelargonium* leaves occurred in those exposed to temperatures between 25° and 38° C. It should be remembered in comparing the present work with that of Winkler that he used the methods of Böhm and Meyer in his studies, that is, floating cut portions of leaves on sucrose solutions, while the writers

inserted the cut petioles in the solution. It might be that this difference in technique would produce slightly different results, but it is the opinion of the writers, based upon the preliminary studies where both methods were tried, that the difference is negligible.



FIGS. 4, 5, 6, 7. Cross-sections of the leaves of the variegated *Pelargonium*.

4, 5. Sections through the light-green areas showing the single celled layer of chlorenchyma, the large chloroplasts in the green cells, and the small leucoplasts in the non-green cells.

6. Section of the albino portion showing the weakly developed leucoplasts.

7. Section of an albino leaf near a vascular bundle, after several hours in a glucose solution, showing the early development of starch in the leucoplasts near the phloem. Arrows mark cells containing particularly well defined leucoplasts.

PLASTIDS.

In the variegated leaves of *Pelargonium*, there may be noted three distinct zones, green, light-green, and non-green. The writers made certain cytological studies to ascertain the distributional and structural differences of the plastids in these regions.

MATERIALS AND METHODS.—The material for this part of the work was taken from plants of the same clon culture as

that used in the physiological studies. Both fresh and killed material was examined. The fresh material was cut by hand and mounted either in water or a weak iodine solution. In the special preparations the material was killed in several fixatives. It was found, however, that an alcohol, corrosive sublimate, acetic acid, formaldehyde mixture gave the best results.

The pieces of leaf to be examined were imbeded in paraffin and sectioned in the usual way at thicknesses varying from 5 to 15 microns, and stained in Haidenhain's haematoxylin, according to the modified technique of one of the writers (Camp, 1931).

Owing to the difficulty of cutting sufficiently thin sections from leaves containing the large starch grains which occur in the non-green portion after treatment, the best preparations were obtained from material which was fairly free from starch.

Results.—In the dark-green portions of the leaves, the chloroplasts were generally distributed in the cells of the spongy and palisade layers of the mesophyll, occasional cell layers being free of them. The light-green areas of the leaf generally contained but one layer of cells with chloroplasts (Figs. 4, 5), while the mesophyll cells of the non-green portions were free of them.

In the non-green portions of leaves which were not treated and which did not contain starch, small leucoplasts were found imbedded in the cytoplasm.

With the killing reagents and stain used, the plastids in the green portions of the leaves stood out very clearly, while those in the non-green portions were poorly defined, often appearing only as slightly denser masses of cytoplasm.

The two types of plastids differed greatly in their structure. The chloroplasts were somewhat uniform in size and shape, appearing as slightly lobed, spheroid structures (Fig. 8). Sections through the chloroplasts showed that they were vacuolate and contained 3 to 5 well defined chambers, supported and partially divided by deeply stained trabeculae which were much thicker than the plastid wall or membrane. Very minute branched strands also connected the trabeculae, but apparently were not a part of the primary structure of the plastid, although in a considerable number of plastids they seemed to have a definite arrangement in relation to the trabeculae (Fig. 9).

In contrast, the leucoplasts occurring in the starch-free, non-green portion showed no internal structure, appearing as irregularly sized, flattened granular masses or plates in the cytoplasm (Figs. 10, 11).

The leucoplasts were difficult to locate in fresh material, and even in the stained preparations were often poorly differentiated from the cytoplasm (Figs. 4, 5, 6, 10). The larger leucoplasts often showed several darker staining groups of granules within. Irregular, elongated and deeply stained bodies resembling chondriosomes also occurred in the cytoplasm of the non-green cells.

FIGS. 8, 9, 10, 11, 12. Plastids in the green mesophyll and leucoplasts and starch grains in the albino mesophyll of *Pelargonium*. (× 2300.)

8. External appearance of the chloroplast.
9. Internal structure of a starch-free chloroplast showing the trabeculae.
10. Surface view of starch-free leucoplasts showing the associated granules and chondriosome-like bodies.
11. Side view of starch-free leucoplasts.
12. Developed starch grain showing the cap-like leucoplast.

The two types of plastids were further contrasted in the manner in which they formed starch grains. In the chloroplasts starch was found in the chambers within the plastids, the number of grains corresponding to the number of chambers in the plastid.

In the leucoplasts, the starch is apparently synthesized on one side or face of the plastid, the starch grain, after considerable

growth, appearing roughly elliptic in outline, the plastid body forming a cap at the end of the grain (Fig. 12). If a plastid membrane is present around the mature starch grain, it is too thin to be detected.

While most of the starch grains in the non-green tissue were roughly elliptic in outline, some of them were irregularly shaped. Compound grains were fairly common, originating either in a single large, irregularly-shaped plastid with several centers of activity or by the crowding and coalescing of the grains from a group of closely associated small plastids.

Evidence gleaned from relative staining reactions, optical activity, and behavior at different temperatures, indicated that the starch formed by the chloroplasts and the leucoplasts is somewhat different.

No evidence of a gradual transition from the normal chloroplasts to the leucoplast was found, the two occurring in their extreme forms in adjacent cells. Nor could any evidence be obtained from the material examined to substantiate the claim of some writers that the leucoplasts of *Pelargonium* are degenerate chloroplasts. A study of etiolated and physiologically disorganized leaves did reveal a gradual break-down and degeneration of the chloroplast, but so far as the writers were able to ascertain they did not become transformed into leucoplasts.

Discussion.—It is generally accepted at present that the plastids of many of the higher plants originate in chondriosome-like proplastids which occur in the meristematic cells. While the writers made no special study of this matter, it has been shown by several investigators (see Schürhoff 1924) that *Pelargonium* is no exception.

The problem of the origin of the two types of plastids is a difficult one to solve for there are undoubtedly a number of factors which influence their development. If both chloroplasts and leucoplasts arise from the same type of plastid primordia, there must be some factor or group of factors operating during the process of differentiation producing the two plastid types. Whatever the factors are that bring about the differentiation, they operate within a very narrow band of physiological activity, for immediately adjacent cells contain chloroplasts or leucoplasts in their extreme forms, and at no time could transition or intermediate plastid types be found.

It is also shown by sections of very young leaves that the differentiation takes place early.

Although it is well known that leucoplasts at certain times may form chlorophyll and function as chloroplasts, no evidence that this is true was found in *Pelargonium*, the variegated areas of the leaves remaining the same from the early stages until senility.

An examination of a single plant gives ample evidence that the differentiation is due to a set of factors which are more effective at one time than at another, for certain leaves will show but little variegation, only a thin margin of non-green tissue being in evidence, while other leaves may be almost entirely white.

The writers' observations indicate that light intensity affects the internal conditions influencing differentiation, for plants grown in bright sunlight tend to have but little non-green tissue, while those grown at the same temperature and humidity, but at a lower light intensity, have leaves with more non-green tissue. Individual leaves occasionally approach an almost complete albino condition.

It is also probable that the physiological gradients of the developing leaf are a factor, for the non-green portion is invariably at the margin of the leaf, and if only a small amount of chlorenchyma is present, it is near the base of one or more of the large veins of the leaf blade.

That the variegated habit is also hereditary has been shown by Baur (ref. in Schürhoff 1924), for crosses between green and variegated plants of *Pelargonium* gave variegated and non-variegated segregates in succeeding generations.

The plastids are morphologically differentiated, for the chloroplasts are irregular spheroids made up of 3 to 5 chambers, the starch, when formed, being deposited within the chambers. The leucoplasts, when starch-free, are discoid structures, often irregular in outline and sometimes optically but poorly differentiated from the granular cytoplasm. When formed, the starch is deposited by one face of the leucoplast, the active portion forming a cap over the end of the starch grain.

Haberlandt (1914) and Zirkle (1926) have shown that this type of starch-forming plastid is vacuolate, the starch grain arising internally and bursting through the plastid after growth. Although some evidence of this could be found in the leucoplasts of the material examined during the first stages of starch

formation (Fig. 7), it is to be remembered that later, only one face of the plastid is ordinarily active, the starch accumulating at the face of the greatest activity.

Reichert (1913) pointed out that starches differ greatly in their physical and chemical properties, and although no extended study of this point has been made by the writers, there were indications that the starches formed by the chloroplasts and leucoplasts of *Pelargonium* differ in their optical properties, iodine reaction, and probably in their gelatinization temperature.

CONCLUSIONS.

In the study of the synthesis of starch in the green and non-green portions of the leaves of the variegated pelargonium (*Pelargonium hortorum* var. *Mme. Salleroi*), the writers came to the following conclusions:

1. Starch synthesis normally does not occur in the non-green portion of the *Pelargonium* leaf, but will occur if the leaf is placed in a solution of glucose, the optimum point for starch formation being approximately a 0.5 molecular concentration.

2. Under normal conditions in the greenhouse, the green tissue contains approximately twice as much sugar as the non-green tissue.

3. Although the non-green tissue of the leaf consistently has a higher pH value than the green tissue, it is thought from comparative studies of *Pelargonium* and other leaves that this condition is not so much correlated with the type of tissue as with its position in the leaf.

4. Cut portions of the leaves, when floated on sugar free oxalic acid solutions of pH values ranging from 2.7 to 6.1 and exposed to fifteen hours of continuous light, synthesize starch in the green tissue; and although the carbohydrates were abundant in the green tissue, no evidence of starch synthesis could be found in the non-green portions. Since at none of the pH values could starch be found in the non-green portions, it is probable that in this type of experiment and under normal conditions in the leaf, the carbohydrases present in the green cells, by hastening the condensation of the photosynthetic products, keep the concentration of soluble carbohydrates in the green cell very low. The sugar in the adjacent non-green cells, in equilibrium with that in the green cells, is, therefore,

still below the threshold for starch synthesis for that type of tissue.

5. When cut portions of the leaves are floated on oxalic acid solutions containing glucose of pH values ranging from 2.7 to 6.1, and exposed to diffuse light, starch is synthesized in both the green and non-green portions; and since the starch is most abundant along the veins and cut edges, this indicates that each portion may independently synthesize starch when supplied with glucose.

6. The pH value of the normal tissue is not the limiting factor in the lack of starch synthesis in the albino portion under greenhouse conditions for the greatest amount of starch is synthesized by the non-green tissue when floated on a glucose solution with a pH value of 4.4, the value for this tissue under normal conditions.

7. When glucose is artificially supplied, starch is synthesized equally well in the green and non-green portions of the leaf at temperatures ranging from 4° to 50° C., indicating that temperature is not a factor in the lack of starch synthesis in the non-green portion of the leaves.

8. The chloroplasts of the green tissue and leucoplasts of the non-green tissue are differentiated in the young leaf while in the primordial condition, nor is evidence found of intermediate or transitional forms to indicate that the leucoplasts are merely degenerate chloroplasts.

9. Although the leucoplasts and the chloroplasts are morphologically different, they are both able to synthesize starch if supplied with glucose.

10. Although there are a number of factors which influence starch synthesis in the non-green portion of the *Pelargonium* leaf, the factors probably directly responsible for the absence of starch under greenhouse conditions are the low concentration of soluble carbohydrates in this tissue and the different points of sugar-starch equilibrium in the green and non-green cells.

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THE REACTIONS OF CERTAIN CLADOCERA TO COLORED LIGHTS OF EQUAL INTENSITY.

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I. INTRODUCTION.

It is well known that cladocera are, at most times, sensitive to light. This fact has given rise to a number of investigations on the relative sensitivity of these animals to light of different wave-lengths.

Experiments of this nature were first performed by Bert (1869). He exposed Daphnia to light from different portions of an electric light spectrum, and found that the animals gathered most rapidly in the green and yellow-green, although they were positive to all colors. Similar results were obtained by Lubbock (1881), Hess (1910), Loeb and Maxwell (1910), Ewald (1914), and Borowski (1927). All these investigators used colored lights produced by a prismatic spectrum, although Lubbock and Ewald also employed colored filters.

Yerkes (1900) found that *Simocephalus vetulus* gathered in the yellow of a Welsbach burner prismatic spectrum, but that when a triangular prism containing India ink was placed between the source of light and the animals, so that the intensity of the red end of the spectrum was cut down to a much greater extent than that of the violet, they tended to aggregate in the blue and violet.

v. Frisch and Kupelweiser (1913), working with Daphnia, found that the animals, which became negative when the light intensity was decreased, and positive when it was increased, were positive to green, yellow, and red, although the intensity was raised, and negative to violet, blue, and blue-green, although the intensity was decreased. Similarly, Becher (1921), using colored solutions, found that *Daphnia magna* was positive to green, yellow, and red, and negative to blue and violet. Koehler (1921) obtained similar results with isolated portions of a prismatic spectrum.

Peters (1926), using a method similar to that of Becher, carried out investigations on a number of species of cladocera. For most of the species he obtained results similar to Becher's.

Scapholeberis mucronata and *Peracantha truncata*, on the other hand, were found to be positive to blue and negative to other colors.

The results obtained by these investigators agree fairly well, but their methods are, in certain respects, subject to criticism. In most cases the apparatus was neither standardized nor calibrated. Various sources of light were used. Often the wave-length transmissions of the colors used were not known. The most common fault was that of ignoring the effect of intensity, and ascribing the effects of colors to wave-length alone.

In order to ascertain quantitatively the relative stimulating effect of different wave-lengths on an organism, it is necessary to eliminate any effects which may be due to differences in intensity, either by making a correction in the results for such differences (Mast, 1917), or by using colors of equal intensity (Visscher and Luce, 1928). In none of the experiments on cladocera were either of these methods used.

The present investigation was undertaken with the object of making a comparative study of the stimulating effect of colored lights of equal intensity on certain species of cladocera.

The author is indebted to Dr. J. P. Visscher, who suggested this investigation, for his helpful suggestions and advice during the course of the work.

II. MATERIALS AND METHODS.

1. *Selections of animals for experiments:*

Investigations were carried out on the following four species: *Daphnia pulex*, *Daphnia magna*, *Moina brachiata* and *Leptodora kindtii*.

Daphnia pulex and *Moina brachiata* were collected in ponds in the vicinity of Cleveland. They were raised in the laboratory in a culture medium made up of unicellular forms of algae growing in Moore's solution, which was made up according to the following formula:

Distilled water	1 liter
NH_4NO_3	0.5 gms.
KH_2PO_4	0.2 "
$MgSO_4$	0.2 "
CaC_{12}	0.1 "
$FeSO_4$ (1% soln.)	10 minims

The formula for this culture medium was taken, with some modification, from one originally used by Klugh (1927).

It is well known that the cladocera normally reproduce parthenogenetically. The eggs are laid in a brood chamber situated between the carapace and dorsal body wall. Here they remain until they are released, producing young animals which are like the adults in appearance. Consequently, it was an easy matter to obtain animals which were not only of the same age, but also alike in genetic constitution. The proceedure was as follows: The individuals of a single brood of young were isolated. When these reached maturity, and produced young, the successive broods were separated. These were used in experiments within twenty-four hours after the first brood had been released. Only females were used, the males being discarded in the few instances in which they occurred.

Specimens of *Daphnia magna* were obtained from a clone derived from a stock kept by Banta at Brown University, and were grown in a manure infusion, made by steeping manure in tap water for a few days, and then straining through several layers of cheesecloth (Banta, 1921). Animals were selected for use in experiments in the same manner as with *Daphnia pulex* and *Moina brachiata*.

The work on *Leptodora kindtii* was done at Franz Theodore Stone Laboratory, at Put-in-Bay, Ohio, in the first week of August, 1931. This species was fairly numerous in bottom tows made in the lake with a number twelve mesh tow net. It was found that the animals could not be kept in the laboratory for more than two or three days, so collections were made every morning, and the animals used the same day. Only adult females were used; these could be readily distinguished by the presence of a brood chamber.

It is desirable, during the course of experiments with colored lights, to keep the animals in a colorless culture medium. Since the medium used for *Daphnia pulex* and *Moina brachiata* was slightly green in color, and that used for *Daphnia magna* was brown, it was necessary to transfer the animals to another medium. A satisfactory one was obtained by filtering the original algal medium, so that practically all the algae were removed. To this the animals were transferred several hours before the experiment. For Leptodora, filtered lake water was used.

Although the animals grown in the laboratory were not kept at a constant temperature, their growth-rate was fairly

constant. *Daphnia pulex* released the first brood of young in seven to eight days, *Moina brachiata* in five to six days, and *Daphnia magna* in twelve to thirteen days. The temperature at which the experiments were performed varied between 19.5° C. and 21.5° C. The temperature of the dark room used in the work with *Leptodora kindtii* was somewhat higher, varying between 25.5° C. and 26.5° C.

2. *Apparatus:*

The apparatus used in these experiments is essentially the same as that used by Visscher and Luce (1928). In fact, the lamps and filters used in this work, which were generously loaned to me by Dr. J. P. Visscher, are the identical ones used in their investigations. Since these are fully described in their paper, only a brief description will be given here.

Thirteen filters were used, of which eight were Corning glass filters, and five Wratten filters. They are listed in Table I, together with their spectral transmissions, dominant wave-lengths, and relative energy transmissions, as given by the distance at which the lamp must be placed for each filter to make the energies equal.

It will be noted that the first three filters in the series transmit some red. It is impossible to obtain a filter for the ultra-violet end of the spectrum, which does not transmit some red. There is no way of blocking out this red, without also blocking out some of the blue or ultra-violet. Since the amount of red transmitted is relatively small, it was decided best to use the filters as they were, and attempt a correction for the red later. This correction was made by determining the percentage of red transmitted, and deducting that from the total value obtained in the experiments.

The lamp used was a 100 watt, 115 volt, gas filled Mazda lamp, which carried, during experiments, the regular city current of 110 volts. The infra-red rays were absorbed by a copper sulfate filter two centimeters thick, and filled with a solution consisting of 57 grams of copper sulfate in two liters of water.

The apparatus was set up as shown in Figure 1. The lamp was enclosed in a light-proof box, with an opening about 5 centimeters in diameter. A copper sulfate cell was placed in front of the opening. The box was movable, and mounted on a track. The aquarium in which the animals were placed

was 40 millimeters square, and 20 millimeters deep, and made of a high grade of slide glass, cemented together with De-Khotinsky cement. A line was marked across the bottom, dividing it into halves, one half toward the source of light, the other away from it. The aquarium was mounted on a stand containing a small microscope lamp, which could be used to light the aquarium from below, thus facilitating the counting of the animals. Between the lamp and the aquarium was

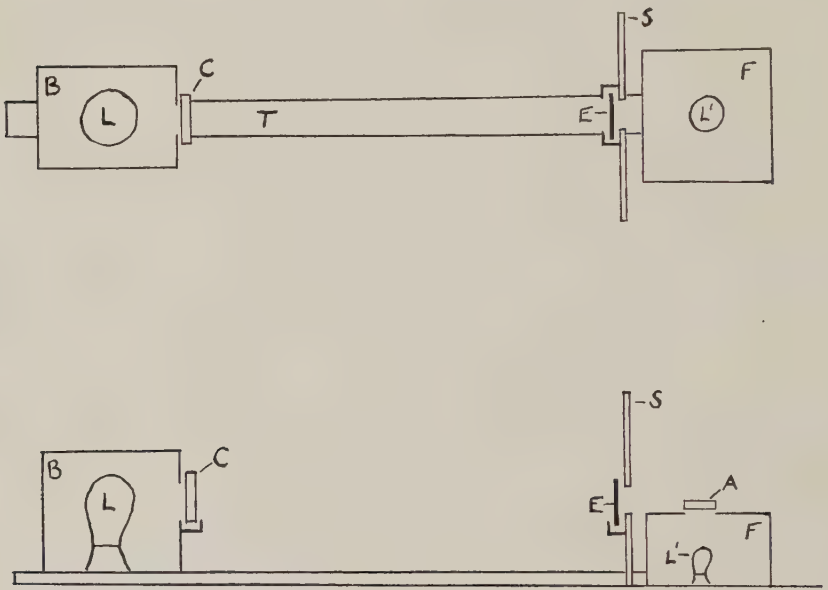

FIGURE 1. Diagrams to illustrate the apparatus used in the experiments. T, track for box (B) containing lamp (L). C, copper sulphate filter in front of opening in box. S, screen holding filters (E). F, aquarium stand containing microscope lamp (L'). A, aquarium.

placed a screen, containing an opening 5 centimeters in diameter, and a slot for the filters. The screen, stand, and lamp box were covered with heavy black paper, and the entire apparatus set up in a dark room.

3. *Method:*

When exposed to white light, *Daphnia pulex* and *Moina brachiata* were found to be neutral, and *Daphnia magna* and *Leptodora kindtii* negative. It was found, however, that they became positive when exposed to certain monochromatic lights. The method used in the experiments is based on this observation.

In carrying out an experiment, a number of animals from a single brood, usually about ten, were placed in the aquarium, and left for several hours in the dark room, to allow them to become dark adapted. They were then exposed to light. They were given three exposures of one minute each (two minutes in the case of *Daphnia pulex*) to each filter, with the

TABLE I.*

List of Filters Used, Showing Their Total Spectral Transmission, Dominant Wave-Lengths, and the Distance of Lamp from Aquarium for Each.

Filter	Total Transmission	Dominant Wave-Length	Distance of Lamp from Aquarium
Ultra C83	315–428 μμ 609–Red End	355 μμ	24.9 cm.
Purple C69	310–485 μμ 690–Red End	370 μμ	42.4 cm.
Purple W35	300–475 μμ 650–700 μμ	420 μμ	44.4 cm.
Blue W49	400–510 μμ	440 μμ	52.6 cm.
Blue C60	335–640 μμ	460 μμ	81.5 cm.
Blue C59	335–690 μμ	480 μμ	93.2 cm.
Blue-green C56	340–700 μμ	505 μμ	100 cm.
Green C52	425–670 μμ	530 μμ	65.6 cm.
Green W58	485–635 μμ	540 μμ	63.2 cm.
Yellow W15	500–700 μμ	590 μμ	102.3 cm.
Orange W22	545–700 μμ	620 μμ	83.0 cm.
Orange C38	540–Red End	640 μμ	77.3 cm.
Red C19	620–Red End	700 μμ	49.2 cm.
White Light	.....	.....	119.2 cm.

The letter "C" after a filter denotes a Corning glass filter. The number after the Corning Glasses refer to the transmission curves shown in Bureau of Staudards Technologic paper 148. The letter "W" denotes a Wratten filter, and the number refers to the transmission curves found in the booklet, "Wratten Filters," published by the Eastman Kodak Company.

*All but the last column of this table is taken from Visscher and Luce (1928).

lamp placed at the proper distance (see Table I). A dark period of twenty seconds was allowed between exposures. In each case, the number of animals in the half of the aquarium toward the light was counted.

It was found that the animals became more positive to light after a series of experiments than they had been at the start. The reaction to the colors, however, was the same, regardless of the order in which they were used. That is, the reaction to a given filter was the same whether it was used at the beginning or at the end of a set of experiments.

III. RESULTS.

In Table II are given the results of several series of experiments on *Moina brachiata*. Tables III, IV, and V give results similarly obtained for *Leptodora kindtii*, *Daphnia magna*, and *Daphnia pulex*. These results are shown more graphically in Figure 2. It is immediately evident from the curves in this

TABLE II.

Results of Experiments to Determine the Distribution of Stimulating Efficiency Among Different Portions of the Spectrum of Equal Energy Content, for Monia brachiata. The Figures Given in Each Set of Experiments are the Total Numbers of Animals Positive to Each Light in Three Exposures.

Moina brachiata.

Average temp. = 21.0° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1.....	7animals	3	8	12	12	14	13	12	17	17	10	12	20	12
2.....	5 "	1	3	2	6	4	4	6	9	13	13	13	14	10
3.....	11 "	13	19	21	23	14	16	18	21	20	15	14	14	11
4.....	10 "	14	14	12	19	14	12	15	17	20	19	21	20	15
5.....	10 "	10	16	16	20	16	19	12	19	20	14	17	17	11
6.....	12 "	18	12	22	20	19	22	27	28	26	22	30	28	20
7.....	12 "	20	16	21	17	16	18	16	14	9	15	15	17	8
8.....	12 "	15	16	21	13	14	16	15	20	19	18	15	17	10
9.....	10 "	27	28	26	26	26	27	25	26	28	28	24	28	21
10.....	11 "	10	13	9	12	13	12	16	17	20	17	18	16	19
Total....	100 animals	131	145	162	168	150	159	162	188	192	171	178	191	137
Percent positive		43.7	48.3	54.0	56.0	50.0	53.0	54.0	62.7	64.0	57.0	59.3	63.7	46.3
Corrected for Red		42.5	46.8	52.4										

figure that the red end of the spectrum is greater in stimulating effect than the blue end. The maximum is in the orange, at about 640$\mu\mu$ for *Daphnia pulex* and *Leptodora kindtii*, and at about 620$\mu\mu$ for *Daphnia magna*. In the case of *Moina brachiata*, there are two maxima of equal efficiency, one in the green at about 540$\mu\mu$ and the other in the orange at about 640$\mu\mu$. There is also a secondary maximum in the blue at about 440$\mu\mu$, not very pronounced for *Leptodora kindtii*, but more definite for the other forms.

It is interesting to note that although the distribution of stimulating effect is similar in these forms, there are differences in the curves for each species. Those for *Daphnia pulex* and *Leptodora kindtii* are most alike. That for *Daphnia magna* differs from these in that the maximum is slightly different, and that the stimulating effect of green is relatively less. While

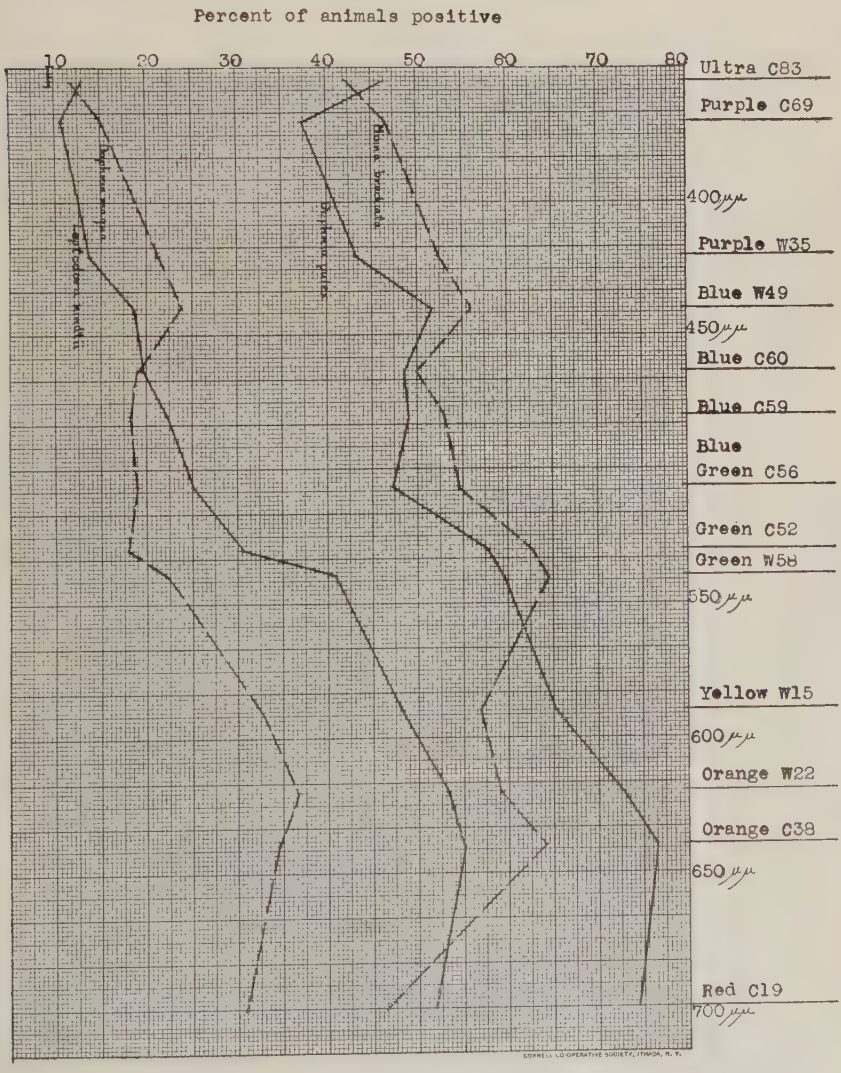

FIGURE 2. Curves showing the distribution of stimulating efficiency among colors equal in radiant energy content.

the curve for *Moina brachiata* appears markedly different from the others, it may be noted that it is quite similar to that for *Daphnia pulex* from the violet through the green; after that the effect is relatively much greater in the latter form.

There is, in the case of *Daphnia pulex* and *Leptodora kindtii*, a slight increase in effect toward the ultra-violet, while in the

TABLE III.

RESULTS OF EXPERIMENTS TO DETERMINE THE DISTRIBUTION OF STIMULATING EFFICIENCY AMONG DIFFERENT PORTIONS OF THE SPECTRUM OF EQUAL ENERGY CONTENT, FOR LEPTODORA KINDTII. THE FIGURES GIVEN IN EACH SET OF EXPERIMENTS ARE THE TOTAL NUMBERS OF ANIMALS POSITIVE TO EACH LIGHT IN THREE EXPOSURES.

Leptodora kindtii.

Average temp. = 26.0° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1.....	7 animals	5	2	3	5	6	6	5	8	9	6	10	11	8
2.....	8 "	4	5	4	6	6	4	5	7	9	13	13	14	17
3.....	10 "	11	10	9	11	11	8	11	11	12	15	12	10	13
4.....	8 "	4	1	3	6	4	6	8	11	14	14	18	17	16
5.....	10 "	3	2	2	2	3	4	6	10	16	16	20	24	22
6.....	8 "	1	0	2	5	5	6	3	9	11	12	13	15	15
7.....	9 "	4	4	7	6	13	13	12	11	15	14	17	16	18
8.....	10 "	2	2	6	3	5	5	6	9	13	21	16	19	17
9.....	10 "	4	4	2	3	3	3	4	3	6	9	11	10	7
10.....	10 "	2	4	4	4	6	6	7	11	9	11	12	14	14
11.....	10 "	3	3	4	5	6	6	6	9	12	14	18	15	8
Total....	100 animals	43	37	46	56	59	67	75	92	126	145	160	165	155
Percent positive		14.3	12.3	15.3	18.7	19.7	22.3	25.0	30.7	42.0	48.3	53.3	55.0	51.7
Corrected for Red		13.1	10.8	13.7										

other two species, the efficiency is lowest in this region. It would have been desirable to test this region further, but this was not possible with the apparatus used, since light from a tungsten filament does not penetrate far into the ultra-violet.

It is also interesting to observe that the effect of red is rather high in three of the species; in fact it is almost as great as that of orange. For *Moina brachiata*, on the other hand, it is scarcely higher than the effect of violet.

IV. DISCUSSION AND CONCLUSIONS.

It is apparent that the results of these experiments differ from those of previous investigators, first, in that here the efficiency of the orange is greater than that of the green, or at least equal to it (*Moina brachiata*), and second, in that here the efficiency of red is relatively high, being, with the exception

TABLE IV.

Results of Experiments to Determine the Distribution of Stimulating Efficiency Among Different Portions of the Spectrum, of Equal Energy Content, for Daphnia magna. The Figures Given in Each Set of Experiments are the Total Numbers of Animals Positive to Each Light in Three Exposures.

Daphnia magna.

Average temp. = 21.0° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1.....	6animals	1	2	1	0	5	5	2	0	1	4	3	6	9
2.....	9 "	1	3	7	3	2	1	3	5	7	6	8	5	9
3.....	14 "	2	7	6	5	2	2	7	5	7	11	16	10	10
4.....	8 "	4	1	9	5	7	8	8	8	8	13	17	17	10
5.....	7 "	7	6	7	6	5	5	6	5	6	8	8	11	9
6.....	13 "	2	3	5	6	4	3	4	4	7	6	10	0	4
7.....	8 "	7	10	11	13	9	11	9	11	11	18	16	16	13
8.....	10 "	3	5	7	12	6	3	2	1	3	8	13	9	9
9.....	12 "	3	3	7	8	6	5	7	4	5	6	5	7	12
10.....	13 "	9	10	9	13	11	12	9	11	12	18	14	14	6
Total....	100 animals	39	50	69	71	57	55	57	54	67	98	110	104	93
Percent positive.....		13.0	16.7	23.0	23.7	19.0	18.3	19.0	18.0	22.3	32.7	36.7	34.7	31.0
Corrected for Red.....		11.8	15.2	21.4										

of *Moina*, higher than that of the green. On the other hand, the results are similar to those obtained by v. Frisch and Kupelweiser, Becher, Koehler, and Peters, in that the animals are, as a rule, more positive to green, yellow, orange, and red, than to blue and violet. The only exception to this is *Daphnia magna*, which is about equally positive to green and blue.

The explanation of the discrepancies between these results and others may lie in one or more of the following factors; physiological condition; age; or the distribution of radiant energy in the spectrum.

The results in question were obtained with animals positive to light. The animals used in these experiments were either neutral (*Daphnia pulex*, *Moina brachiata*) or negative (*Daphnia magna*, *Leptodora kindtii*) to white light. Mast (1917) has shown that for certain organisms the distribution of stimulating effect is the same whether the organisms are positive or negative

TABLE V.

Results of Experiments to Determine the Distribution of Stimulating Efficiency Among Different Portions of the Spectrum, of Equal Energy Content, for Daphnia pulex. The Figures Given in Each Set of Experiments are the Total Numbers of Animals Positive to Each Light in Three Exposures.

Daphnia pulex.

Average temp. = 21.5° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1.....	10 animals	11	8	12	8	15	13	8	10	14	17	20	24	19
2.....	10 "	16	11	10	10	14	18	20	20	22	25	23	26	23
3.....	10 "	12	9	8	12	11	10	7	15	22	20	23	22	23
4.....	10 "	15	11	12	17	15	13	16	16	23	19	21	25	25
5.....	10 "	18	17	17	24	21	20	22	24	24	19	24	23	27
6.....	10 "	17	12	13	23	22	22	21	23	18	22	22	19	17
7.....	10 "	18	16	14	16	18	16	13	20	19	19	21	23	19
8.....	10 "	14	10	19	14	8	14	10	16	10	14	14	20	21
9.....	9 "	10	10	12	16	9	7	8	9	9	15	23	22	26
10.....	6 "	5	7	11	7	6	7	10	12	9	16	16	14	12
Total....	95 animals	136	111	128	147	139	140	135	165	170	186	207	218	212
Percent positive		47.7	38.9	44.9	51.6	48.7	49.1	47.4	57.9	59.6	65.3	72.6	76.5	74.4
Corrected for Red		46.5	37.4	43.3										

to light. Although this has not been definitely shown for cladocera, it is rather to be expected, particularly if the distribution of stimulating effect depends on the presence of a fixed photosensitive substance. Consequently, the factor of physiological condition is, to a great extent, ruled out. A series of experiments on positively phototropic animals would be required, however, to settle this point definitely.

It is known that the phototropic reactions of cladocera change with age. Newly hatched animals are positive to light at all temperatures. As they grow older, however, they become

neutral or negative to light, and are positive only at low temperatures, the range depending on the particular species. This indicates primarily a change in physiological condition, but there is also a possibility that the nature of the photosensitive substance may change with age. In previous work, animals in various stages of development were used; here, the animals used were as nearly as possible of the same age. However, since animals of only one age were used, nothing definite can be said here concerning this factor.

It may be noted that in practically all previous investigations with Daphnia, in which the region of maximum efficiency was found to lie in the green or yellow, the monochromatic light was produced by a prismatic spectrum. The radiant energy of a prismatic spectrum increases from the blue to the red, slowly at first, then more rapidly (Mast, 1911, p. 306; 1917, p. 490). Thus, the radiant energy of the orange and red used in such experiments is much greater than that of the green and yellow. It is quite probable that the energy of the orange and red was, in cases where a prismatic spectrum was used, too great to elicit a positive response, especially since these animals are positive only within a limited range of intensities. With colors equal in energy, however, such a probability is eliminated; here the response to color is not hidden by an opposite response to intensity. This factor is the one which most readily explains the discrepancies between the results of these and previous investigations.

It may be concluded, accordingly, that the animals investigated are more strongly stimulated by some wave-lengths than by others, when the intensity of the various wave-lengths is equal. There is a region of maximum stimulating efficiency in the orange (620–640$\mu\mu$) for all the species investigated, and also an equal maximum in the green at about 540$\mu\mu$ for *Moina brachiata*. The stimulating effect falls off greatly toward the violet end, with a secondary maximum in the blue at about 440$\mu\mu$, and very little toward the red, except in the case of *Moina brachiata*. That these reactions are specific effects of the wave-lengths involved, and are not due merely to the amount of ultra-violet transmitted by each filter, as Becher maintains, is evident from the fact that not only is little ultra-violet transmitted by any but the purple filters, but whatever is transmitted is almost completely absorbed by the three layers of glass through which the light passes.

A comparison of the curves in Figure 2 warrants the further conclusion that the photosensitive substances in these four species, although fundamentally similar, are specific for each species. It is interesting to note that the curve for *Daphnia pulex* is more similar to that for *Leptodora kindtii* than it is to that for *Daphnia magna*. This indicates, as do the results of Mast (1917) and Hecht, (1928), that distribution of stimulating effect in the spectrum is not correlated with the degree in which the species are related.

V. SUMMARY.

1. Four species of cladocera (*Moina brachiata*, *Leptodora kindtii*, *Daphnia pulex*, and *Daphnia magna*) were exposed to a series of thirteen colored lights of equal intensity, and the percentages of the total number positive to each light determined.

2. Orange light (620–640$\mu\mu$) was found to have the maximum stimulating effect for all the species investigated. For *Moina brachiata*, the efficiency of green light (about 540$\mu\mu$) was approximately equal to that of orange. The discrepancy between these results and those of previous investigators, who maintained that green light had the maximum stimulating efficiency, is most probably due to the fact that colors equal in intensity were used in these experiments.

3. The stimulating efficiency falls off greatly toward the violet, with a secondary maximum in the blue at about 440$\mu\mu$, but very little toward the red, except in the case of *Moina brachiata*, where the effect of red is very low.

4. The curves for the distribution of stimulating efficiency, although essentially similar for these forms, are nevertheless different in certain details for each species. This indicates that the photosensitive substances are specific for each species, although fundamentally similar.

5. The similarity of the curves for two species is not correlated with the degree of relationship of the species since the curve for *Daphnia pulex* is more similar to that for *Leptodora kindtii* than it is to that for *Daphnia magna*.

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The Emergence of Life.

This book is an attempt to interpret Emergent Evolution on the basis of logical and mathematical theories which have been prominent in recent scientific discussion; and also to gather up suggestions from the classic philosophers. The basic interpretation is an idealistic theory of reality. The monadology of Leibniz is given a central position, though reinterpreted in a manner deemed necessary in the light of later thought. The emergence of life is regarded as following lines capable of accurate description in terms of mathematical logic. This calls for a reduction of structure to infinitesimals of the infinite order, and for a discussion of continuity and discontinuity in the light of mathematical-logical analysis of these concepts. Contributions are drawn from a wide range of scientific literature, physical and biological.

The result is an imposing array at certain points of mathematical and logical formulae, though their connection with the thesis presented is often so briefly given that the necessity of the connection and relevance to the theory are not clearly evident. The massing of differential equations, radicals, vector analyses, theory of groups, etc., seems more like a display of elaborate erudition than a convincing straightforward argument. To the general reader it looks quite forbidding. To the specialist it might easily look over-ambitious. An effective synthesis in a single volume might well dwell longer upon fundamental principles, rather than attempt to present too much detail, fundamental as this is ultimately.

—A. E. Avey.

The Emergence of life, by J. B. Burke. viii+396 pp. Oxford Univ. Press, 1931. $7.50.

DOMINANCE IN MAN, WITH ESPECIAL REFERENCE TO POLYDACTYLISM.*

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The determination of the dominance or recessiveness of any human character often presents difficulties. Most of the known human hereditary characters are recorded in small family histories, which by themselves are not sufficient to establish the dominance or recessiveness of the factor. Yet a factor which appears in each generation recorded, even though the family history be a small one, is usually stated to be a dominant. That this statement may not always be true can be readily shown by the histories of polydactylism given below.

As human heredity becomes better understood, the genetecist is more often called upon to give advice on the probability of certain characters appearing in the offspring of certain marriages. The requests are frequently from prospective mothers who wish to be reassured in the matter of certain undesired traits which have appeared in their ancestry. A thorough and accurate knowledge of the mode of the inheritance of any character is of course necessary before any statements as to the probability of its appearance in the offspring may be made, and the genetecist may well be chary of his advice.

That the difficulty of distinguishing a true dominant in man is not always understood may be realized from the following quotation from the recent syllabus of the introductory course in the biological sciences at a large and well known University. The statement is made, in connection with human heredity, that "It is not difficult to determine whether a trait is a dominant or recessive. If a trait appears in at least one of the parents, in at least one of the grandparents, and in at least one member of other ancestral generations, it must be dominant." The arbitrary application of such a principle may result in errors, especially in human pedigrees which are frequently short and which almost invariably start with a generation which actually shows the character.

*Studies in Human Inheritance VIII.

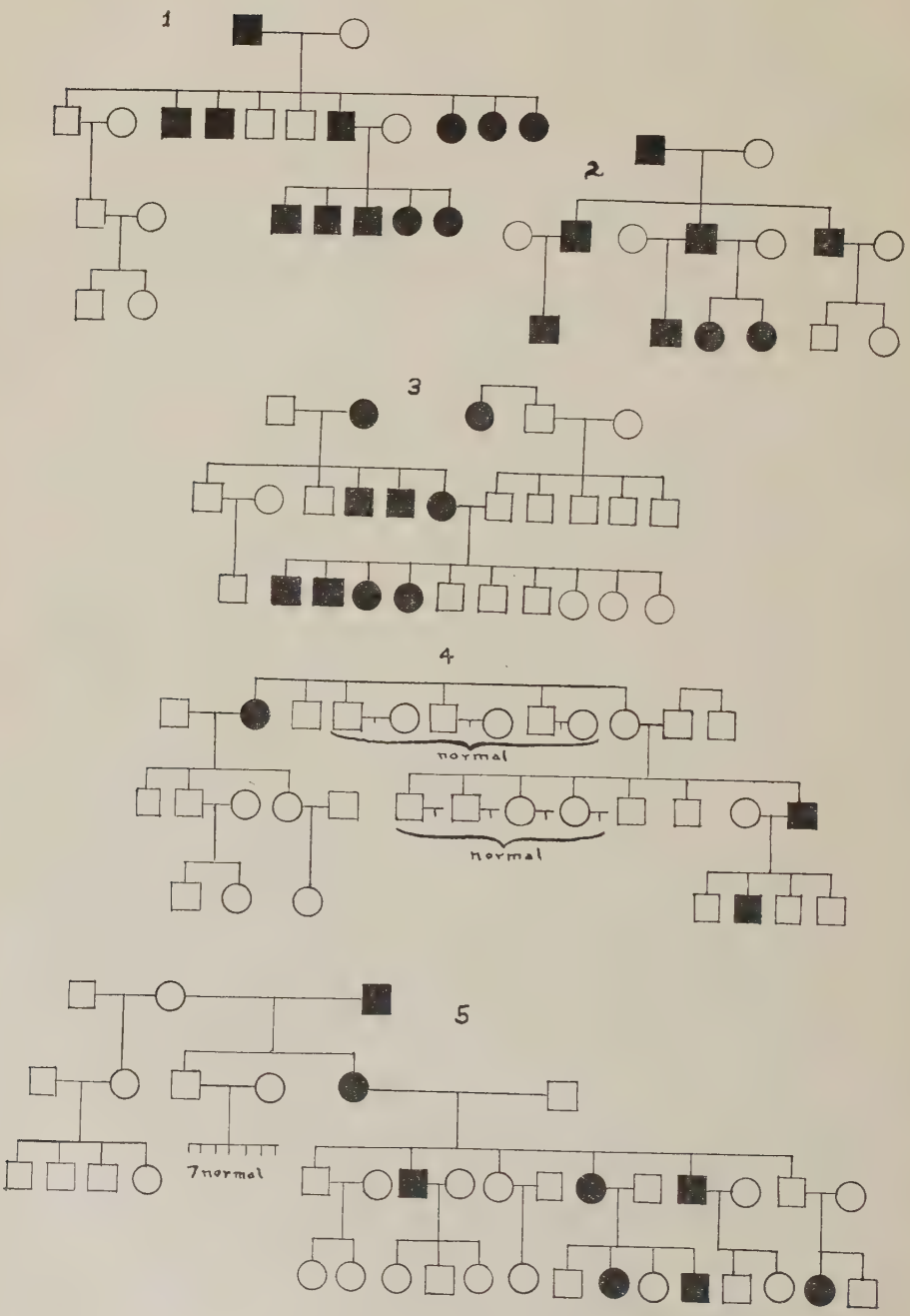
As a case in point may be cited some evidence on hand in our laboratory on the question of polydactylism. This character in white people is usually considered a dominant, because in general it appears to be handed down directly from parent to offspring. The available cases are comparatively few, however, and may not necessarily indicate dominance. The following new pedigree is typical of the kind usually recorded (Figure 1).

Here the character is handed down for three generations without a break. As is normally the case, however, nothing is known of the generation preceding the first in which the character is recorded. Such a pedigree would immediately be stamped as that of a dominant character. The pedigree to be given next will, however, show that this must not be taken for granted.

It is admitted that for the character to be recessive in the foregoing pedigree the mothers of the polydactylous children must in both cases have been heterozygous, and that the odds against this being so are enormous, but it must not be forgotten that these conditions are the very ones whose occasional occurrence bring the pedigree to our attention. When we read a story of a succession of amazing incidents happening to a man, we are prone to dismiss it with the observation that such a series of things would almost never happen, forgetting that the very fact that they did in this case happen may provide the only motive for the writing of the story. Thus the isolated occurrence of a character in a family passes by unrecorded time and again, while the repeated occurrence, from whatever cause, is noted and recorded. We have on record several cases of polydactylism in white people in which neither parent showed the character.

More critical data are provided in the case of polydactylism in negroes. The following pedigree was recently obtained in Columbus with the aid of Dr. J. H. Mitchell, (Figure 2).

This would appear to be the regulation dominant, and would be unhesitatingly called so if the principle cited at the beginning of this paper were followed. However, in a previous paper, one of us (L. H. S.) has shown that polydactylism in negroes is a recessive. It is not impossible that this is the same gene. Many parts of the original pedigree (Snyder, 1929) showed characteristics common to a dominant trait. Only upon careful examination of the more extensive record of the family history did it appear that the character must


1
2
3
4
normal
normal
5
7normal

be recessive. Figure 3, another new pedigree of polydactylism in negroes, while again appearing at first glance dominant, shows more clearly that it may well be recessive, as the character appears in both lines of the family.

Finally figure 4, likewise a new pedigree in negroes, shows a clear case in which neither parent showed the character and yet transmitted it to a child. While this one case might only indicate the presence of an inhibitor or some other interaction of the factors concerned, reference to the original pedigree cited above will show this to be of frequent occurrence.

An interesting pedigree is offered in this connection in figure 5. This is a case of syndactyly in whites. The character appears dominant, but one case is shown where an abnormal child was born of normal parents. This family is especially interesting in that all syndactylous individuals had also six toes, while the normal individuals had the usual five toes. The number of fingers was in all cases normal. This may indicate a close linkage between syndactyly of the hands and polydactyly of the toes in this family.

In the case of a human character, then, which in a small pedigree or a series of small pedigrees appears in each generation, it is not adequate to arbitrarily designate it a dominant. The following possibilities must always be considered.

1. The factor may, of course, be a true dominant, a fact, however, the proof of which will require far more than the usual small pedigrees.

2. It may be a recessive, most frequently brought to our attention and recorded in pedigree form in those relatively rare cases in which an individual showing the character has married a heterozygote.

3. It may be brought about by any one of duplicate genes, certain of which may be dominant and others recessive.

4. There must always be considered the interaction and epistatic relationships of more than one pair of factors.

5. The character may occasionally appear due to a purely developmental abnormality simulating the hereditary condition, thus complicating the interpretation of family histories.

It must not be forgotten that even if the gene apparently is a dominant we usually have no way of knowing the composition of the homozygous mutant form. In many cases this may be lethal, so that the gene is really intermediate.

If one form of polydactylism is really dominant, as has been considered, the occurrence of a completely recessive form in other families throws an interesting side-light on Fischer's theory of the evolution of dominance. It becomes necessary to explain why one form of polydactylism has become recessive while another phenotypically indistinguishable form is dominant. This fact would favor Wright's suggestion that while the most frequently *occurring* mutations are recessive, those actually fixed in evolution may be either dominants or recessives, thus making it unnecessary to assume the evolution of dominance in new type genes.

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Heredity.

The second edition of a genetics text-book by a working genetecist makes its appearance five years after the publication of the original edition. The new book is an improvement over the old one, most especially in the addition of problems to be worked at the conclusion of the various chapters on types of inheritance. Much new material on human inheritance and its various practical applications is included, and certain worth-while additions are apparent in the fundamental chapters.

The author has proceeded on the commendable assumption that many students who would otherwise not obtain any instruction in biology can be led to a knowledge of the subject through an interest in human biology and especially human heredity. The book therefore assumes no previous biological instruction for its readers. Certain elementary facts concerning cells and development are therefore included where needed. The book appears to be exceptionally well suited to the elementary course in heredity, where an increasing knowledge of human inheritance makes it essential that more and more of this valuable material be used in developing an intelligent interest among students.—L. H. S.

Heredity, by A. F. Shull. Second edition, xv+345 pp. New York, McGraw-Hill Book Co., 1931. $3.00.

RANGES OF pH TOLERANCE OF THE LEMNACEAE.*

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The hydrogen ion concentration is extremely important in many of the chemical reactions which take place within any plant structure and must be taken into consideration in any attempt to understand and explain those factors which may influence the growth, reproduction, abundance and distribution of the Lemnaceae or duckweed family.

Mineral salts in water in which aquatic plants are growing may: (a) furnish raw materials, (b) act as catalytic agents, (c) determine acidity and alkalinity of the medium and (d) provide a balanced solution. In addition, acids and alkalies may have a toxic effect upon living cells by changing their permeability.

The important effect of the extremes of pH concentration upon plant growth in general, being generally accepted, the present paper is a record of various experiments and field observations to determine to what extent the pH concentration ranges commonly found in the waters of the state of Ohio limit or promote the growth and distribution of the various species of Lemnaceae. The major portion of this work was done between October, 1928, and June, 1929, and this report is a revision of a paper prepared at that time.

In all, more than 660 hydrogen ion determinations were made of: (a) the waters in which 7 species of Lemnaceae were growing in 36 Ohio counties, (b) the organic media in which these same species were growing in greenhouse cultures and (c) various buffered inorganic salt solutions with pH values arranged in series.

METHOD OF MAKING DETERMINATIONS.

The colorometric, the quinhydrone and the hydrogen electrode methods of pH determination were compared and the quinhydrone method was found to be superior to the others in every way for the purposes of these experiments. All of the determinations given were made by that method. Samples of

*Papers from the Department of Botany, Ohio State University, No. 296.

water to be tested (free from duckweeds or other organic matter) were collected in 40 or 50 cc. stoppered, chemically clean glass bottles and carefully labeled with all necessary data. The actual determinations were made in the laboratory. Samples of greenhouse cultures were tested immediately after collection. Field samples were usually tested within a few hours after collection and at temperatures similar to those at the time of collection. Duplicate samples thus collected would check to within .01 pH or less and often gave identical readings to the third place. Samples redetermined three weeks after collection showed only a very slight variation from the original reading. Thus the method of determination used seemed to be an extremely accurate and practical one.

The pH concentrations of the stream waters of the state of Ohio, as determined from a limited number of samples, range from about pH 5.6 to pH 8.8, although many springs and stagnant bodies of water, especially swamps and bogs, may range down to pH 4. Most of the stream waters of the state are on the alkaline side of the neutral point, especially those of the western half of the state in the limestone areas.

Many of the streams of the acid-forming sandstone regions of the Alleghany Plateau are somewhat acid, especially in the sections covered by the Black Hand formation of the Sugar Grove region. More than 700 Ohio stream water pH determinations by the colorimetric method were made by E. L. Wickliffe, Chief of the Bureau of Scientific Research, Ohio Division of Conservation (unpublished). His results showed that the stream waters of the eastern half of the Lake Erie drainage average pH 7.5, the western half pH 8.0, the unglaciated Ohio drainage pH 7.27 and the glaciated Ohio drainage ph 7.9.

It is very important to remember that the pH concentration of any body of water is not a fixed value, but is highly variable. The extremes of pH values over a period of time are probably of more importance in effecting plant life than just the average pH values of the same period. pH values of water areas supporting duckweed populations are known to vary with (a) dissolved soil constituents, (b) temperature, (c) presence of buffers, (d) time of year or season, (e) amount of rainfall, (f) decay of organic matter and other factors.

Rather large variations in pH values result from temperature changes alone, especially in poorly buffered solutions. Low temperatures tend toward acidity, high temperatures

toward alkalinity. This is largely due to the greater amounts of carbon dioxide dissolved at the lower temperatures. Most of the very acid determinations made of bog waters are partly due to the lower temperatures of the water among bog plants. Samples of water collected only a few feet away from the edge of a sphagnum bog were often distinctly alkaline. A sample of distilled water at 23 degrees C. had a pH of 4.98, but when boiled for a few minutes to drive off the dissolved carbon dioxide, gave a pH value of 6.8. pH-temperature curves, made from readings taken by E. L. Wickliffe at Buckeye Lake over a period of several months, showed a rather distinct correlation between the two.

TABLE I.

Species	Number of Times Occurring in pH Values of									
	4.6 to 5.0	5.0 to 5.4	5.4 to 5.8	5.8 to 6.1	6.1 to 6.4	6.4 to 6.7	6.7 to 7.0	7.0 to 7.3	7.3 to 7.6	7.6 to 7.9
Spirodela polyrhiza	....	....	....	4	11	36	39	46	10	....
Lemna trisulca	....	....	8	5	28	35	7	2	....	....
Lemna minor	....	6	14	9	46	51	28	16	10	....
Lemna cyclostasa	....	....	....	2	6	4	1	....	....	....
Wolffia columbiana	....	....	....	5	14	23	21	12	10	....
Wolffia punctata	....	....	....	....	2	10	11	8	10	....
Wolffiella floridana	....	6	5	5	6	....	....	....	....	....

1. *pH Determinations of Water Media of Wild Plants.*

Table I summarizes the number of times each of the seven species studied occurred in water of the several pH ranges. The results include 212 determinations of water areas in 36 Ohio counties in which one or more species of duckweeds were found growing. Note that *Lemna cyclostasa* and *Wolffiella floridana* have a very restricted distribution in Ohio.

2. *pH Determinations of Greenhouse Cultures.*

A total of 228 pH determinations were made of the water media containing organic matter in which the seven species were growing under greenhouse conditions. Most of these determinations were made from November, 1928, to June, 1929. Cultures tested were of plants growing in tap water or pond water to which had been added a quantity of soil or crushed

stone of all types available, various fertilizers, manures, ground peat or other organic matter. The media produced varied from about pH 4 to pH 8 and made it possible to observe the plants in a wide range of growth conditions. Check cultures were made of each medium type prepared to aid in the interpretation of results. All pH determinations were checked by testing duplicate samples.

The size, general condition and rate of growth of the plants in each case, were carefully noted. Frequent renewals of the

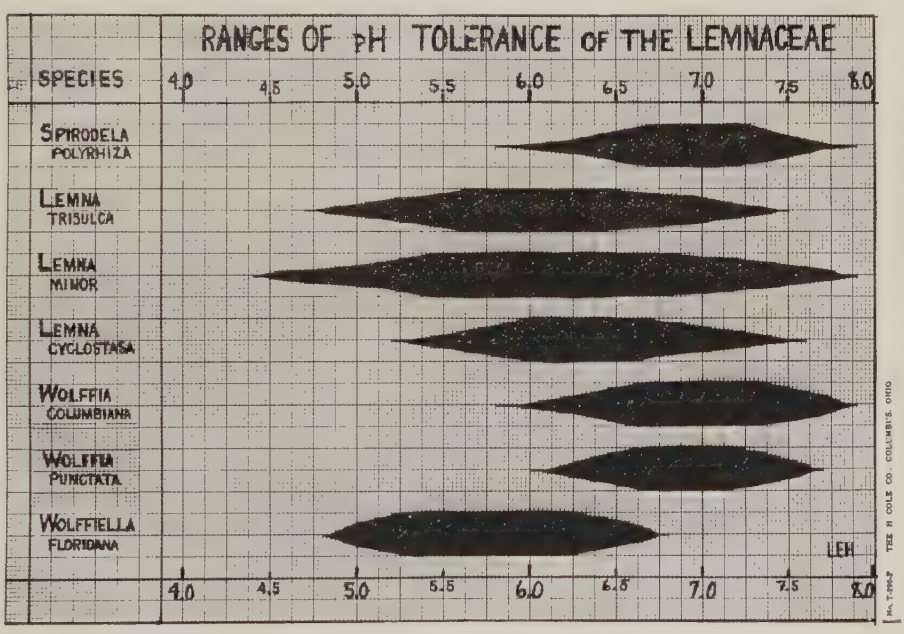
TABLE II.

Species	pH Values Accompanying		
	Good Growth	Fair Growth	Poor Growth
Spirodela polyrhiza.....	6.6 to 7.3	6.4 to 6.6 7.4 to 7.6	5.8 to 6.4 7.6 to 7.9
Lemna trisulca.....	5.6 to 6.5	5.2 to 5.6 6.5 to 7.2	4.6 to 5.2 7.2 to 7.5
Lemna minor.....	5.4 to 6.8	5.0 to 5.4 6.8 to 7.4	4.5 to 5.0 7.4 to 7.8
Lemna cyclostasa.....	6.0 to 6.7	5.7 to 6.0 6.7 to 7.0	5.2 to 5.7 7.0 to 7.6
Wolffia columbiana.....	6.5 to 7.4	6.3 to 6.5 7.4 to 7.7	5.8 to 6.3 7.7 to 7.9
Wolffia punctata.....	6.5 to 7.3	6.3 to 6.5 7.3 to 7.6	6.0 to 6.3 7.6 to 7.7
Wolffiella floridana.....	5.2 to 6.2	5.0 to 5.2 6.2 to 6.5	4.8 to 5.0 6.5 to 6.8

medium to remove bacterial or algal growth, usually resulted in more rapid growth. There was considerable evidence to show that the pH value for best growth varies considerably with the composition of the medium. Plants in media containing an abundance of organic matter were tolerant of somewhat wider extremes of pH plants growing in media entirely or almost lacking in organic matter. As might be expected, plants in culture jars grew in a somewhat wider range of pH than plants of the same species occupy under natural conditions. A summary of growth results is shown in Table II.

3. *Growth of Plants of Seven Lemnaceae Species in Various Buffered Inorganic Salt Solutions with pH Values Arranged in Series.*

In these experiments a Clark (1925) series of buffer solutions was used. Cultures of 10 to 50 plants of each species were placed in 100 cc. wide-mouthed glass bottles with media of pH values as follows: 1.2, 2, 3, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 9 and 10. The medium used was made of equal volumes of



Clark's buffer solutions and Knop's solution. Later the experiment was repeated using Crone's and Shive's solutions. Also the experiment was repeated using McIlvaine's buffer solutions, but the results obtained were so nearly identical with those where Clark's solutions were used, that any of the variations in growth of the cultures appeared to be the actual effects of the pH values and were not seriously modified by any toxic or beneficial effects of the salts.

Where the plants remained alive, the old media were replaced with new solutions. In a few cases renewal was made every two or four days, but no differences in results were noted when compared with cultures which were changed at the usual

weekly periods. The pH of the media in each case was checked by the quinhydrone method at the beginning of the experiment and once (sometimes more often) each week thereafter. Where plants remained alive, the cultures were continued for a 12-week period.

All of the species in the pH 1.2 media died in less than an hour, the roots dying first, shriveling commencing at the tip and proceeding upward toward the point of attachment at the node. In the strong acid solutions, the *Wolffias* died first, then *Spirodela* and lastly the *Lemna* species.

In the literature, only two references were found concerning ranges of pH tolerance of any duckweed species. Clark (1926) grew *Spirodela polyrhiza* in solutions ranging from pH 4.4 to 4.8 and reported best growth from pH 4.6 to 4.8. This does not agree with my results or with those of Deuber (1926), who found that the same species made best growth from pH 6.2 to pH 6.8.

A summary of the results for each species is as follows:

1. *Spirodela polyrhiza.*—This species died in all of the media of pH 5 or less. Plants in pH 5.5 and pH 6 made poor growth, a few plants died and many resting plants were produced. Plants from pH 6 to pH 7.5 made vigorous growth and multiplied rapidly. At pH 8 very poor growth took place, but the plants remained alive 6 weeks and produced resting plants abundantly. More alkaline solutions killed the species.

2. *Lemna trisulca* died at pH 5 or below and at pH 8 or above, made poor growth at pH 5.5 and 7.5 and good growth from pH 6 to pH 7.

3. *Lemna minor* became pale in color and soon died at pH 4 or less and at pH 8 or more. Poor growth was made at pH 4.5 and 5.0. Good growth was made from pH 6 to pH 7.5.

4. *Lemna cyclostasa* died at pH 5 or below and at pH 8 or above, made poor growth at pH 5.5 and 7.5 and good growth from pH 6 to pH 7.

5. *Wolffia columbiana* died at pH 5.5 or below, made poor growth at pH 6, vigorous growth at pH 6.5 to pH 8, poor growth again at pH 8.5 and eventually died, but lived a number of days even at pH 9 and 10.

6. *Wolffia punctata* gave results almost identical with those of *W. columbiana* except that the species was slightly less tolerant of the pH extremes.

7. *Wolffiella floridana* grew only from pH 5 to pH 6.5.

SUMMARY AND CONCLUSIONS.

1. The pH concentration, though not always a limiting factor in our waters, is often an important one in affecting growth and distribution.

2. Some factor other than pH must be used to explain the total absence of duckweeds in a number of important bodies of water in the state. Examples: Bonnett Lake, Holmes Co., pH 6.34; West Swamp, Westerville, Franklin Co., pH 6.96; Chippewa Lake, Medina Co., pH 6.31; and Lake Brady, Crystal Lake, Muzzey Lake and Lake Pippen, all in Portage Co., with waters of pH 7.07, 5.77, 6.55 and 6.37, respectively.

3. *Spirodela polyrhiza*, almost without exception, is deeply pigmented wherever found in alkaline waters. *Lemna minor* frequently produced some red pigment in waters of pH 7 to 7.9.

4. *Spirodela polyrhiza* was found in waters ranging from pH 5.9 to 7.9 and was abundant from pH 6.3 to 7.5.

5. *Lemna trisulca* grew in waters ranging from pH 4.9 to 7.3 and abundantly from pH 5.1 to 6.7. This species, however, showed a marked preference for the cool acid waters of bog types.

6. *Lemna minor* showed a marked tolerance for pH variations, being found from pH 4.4 to 7.9 and abundantly from 5.1 to 6.7, a tolerance range including the pH ranges of tolerance of all of the other Ohio species.

7. *Wolffia columbiana*. Range of pH 5.9 to 7.8. Best growth and most abundant from pH 6.4 to 7.4.

8. *Wolffia punctata*. Range of pH 6.0 to 7.7. Best growth and most abundant from pH 6.4 to 7.4.

9. *Wolffiella floridana* tolerated pH ranges of 4.8 to 6.8. This species grows best among the abundant organic matter of bogs or boggy-swamp types.

10. The following graph shows the ranges of pH tolerance of each species as indicated by the results of the three sets of experiments and pH determinations. The width of the bands following each species indicate the frequency of occurrence and the limits of good growth of each species for each pH value.

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Progress in Microbiology.

This is the third book to appear in the "Century of Progress" series published in connection with the Century of Progress Exposition. It is an exceedingly interesting account of the part microbes have played and are playing in man's varied activities. The first thought in the minds of many on hearing the word microbe is "disease." This story of microbes, while taking full account of the important part played by microscopic forms in disease, draws interest as well to the useful and essential activities of such forms in agriculture, industry, sewage disposal and other of man's fundamental problems. The development of the story of microbes and man is so clearly and instructively drawn that the book should appeal to a wide circle of readers among those interested in keeping informed on modern progress in the sciences.—L. H. S.

Man and Microbes, by STANHOPE BAYNE-JONES. x+128 pp. Baltimore, The Williams and Wilkins Co., 1932. $1.00.

The Story of Living Things.

A series of lectures given at the University of California has grown into this very excellent account of the evolution of the biological sciences. The author has the rather rare faculty of writing an historical account in such a way that one reads it with a sense of pleasure rather than as a duty. The book is a rather complete account of the development of biological knowledge, theory and philosophy. The men concerned with such development are made vital personalities, and their beliefs and influence are set in relief against the unfolding background of increasing knowledge.

The author, while trying to be as fair to the mechanists as possible, is at heart a vitalist. The book begins and ends on the same note—a belief that life is unique and not entirely mechanistic.

No student of biology, beginner or experienced investigator, should fail to read this thoroughly readable history of his science.—S.

The Story of Living Things, by CHARLES SINGER. xxxv+572 pp. New York, Harper and Bros., 1931. $5.00.

THE REBUILDING OF MOUNDS OF THE ANT, POGONOMYRMEX OCCIDENTALIS, CRESS.

ARTHUR C. COLE, JR.,
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The mound of *Pogonomyrmex occidentalis* passes through three stages of development. The first is represented by a small crescentic pile of earth arranged by the queen at the origin of the formicary; the second, the crater type of mound, usually present during the second year; and the third, the dome- or cone-shaped mound of the fully developed formicary. The time required for the complete development of the mound apparently varies with the number of workers comprising the colony and also, to a great extent, with the environmental conditions present throughout the period of mound construction. In the majority of colonies three years are required for the natural development of the mounds, while for others shorter periods are evident. The writer is inclined to believe that mounds of *occidentalis* are fully developed only when they possess rather sharp mound apexes. If this is true some never reach their possible limits.

Strong northwesterly winds, prevalent over the arid sections of Idaho, contribute their share to incomplete mound development, and, in some cases, to complete mound destruction. This is especially true in unprotected areas where the soil is fine and loose. Generally, only a short time is required for the workers to rebuild mounds partially levelled by the wind. A comparison was made of the time required for the rebuilding of wind-leveled mounds with that for the rebuilding of those mounds which were artificially-leveled by hand, the results of which appear in Tables I and II. These data were taken in the vicinity of Twin Falls, Idaho, during the summer of 1931. The number and position of the nest entrances remained fairly constant, and in only one case, of the mounds under observation, was an additional entrance produced during the rebuilding process. The tables illustrate the fact that, in most cases, the mounds were rebuilt with slightly greater dimensions than the

original structures possessed. The rate of rebuilding is apparently proportional to the numerical strength of the colony, as is also the case during the normal building process. Therefore, mounds leveled or partially leveled in the above fashions are built with greater rapidity than are the original structures.

TABLE I.

The Rebuilding of Artificially-leveled Mounds of *Pogonomyrmex occidentalis* Cr.

Mound Number	Height in Inches Before Leveling	Height in Inches After Rebuilding	Time Required, in Days, for Rebuilding
1	15.2	16.1	20
2	15.6	15.8	17
3	14.2	14.7	23
4	16.1	16.3	21
5	15.8	15.7	17
6	14.3	14.7	20
7	15.4	16.0	28
8	16.0	16.1	21
9	22.4	21.8	34
10	15.4	15.9	23

TABLE II.

The Rebuilding of Wind-swept Mounds of *Pogonomyrmex occidentalis* Cr.

Mound Number	Height, in Inches, of Wind-swept Mounds	Height, in Inches, After Rebuilding	Time Required, in Days, for Rebuilding
1	14.1	15.0	12
2	13.6	14.4	12
3	13.8	14.9	14
4	13.2	14.2	18
5	14.2	14.8	17
6	18.5	19.1	12
7	13.9	22.4	15
8	13.4	15.8	17
9	13.7	15.1	19
10	14.3	16.3	21

NESTS OF THE ANT, FORMICA SUBPOLITA MAYR, IN THE WESTERN UNITED STATES.

ARTHUR C. COLE, JR.,
Ohio State University.

Formica subpolita has a wide distributional range. The writer has collected it from Minnesota, South Dakota, Wyoming, Idaho, Utah, Nevada, Arizona, Oregon, and California, while Wheeler[1] has further listed it from Colorado and Washington. The nests are found in a variety of habitats, ranging from the hot, dry desert sands to the cooler and more moist plains. They are especially common in southern Idaho and northern Nevada. The altitude range of the insect seems to lie between 2,000 and 6,000 feet. Numerous specimens have been taken by the writer at Cloud Cap Inn, on Mount Hood, Oregon, at an altitude of approximately 6,000 feet, on the rocky, almost vegetationless slopes. There the colonies consisted of only a few individuals, while under more favorable conditions they are generally a great deal more populous.

The nests of *subpolita* are commonly under rocks and only the superficial galleries and chambers are exposed to view when the rocks are removed. Nests have been found, however, in different situations. The writer discovered one nest under dry cow dung, while Wheeler[2] states that *subpolita* occasionally constructs large crater-mounds.

The nest openings are usually regularly circular in outline but vary in size and numbers, as do the galleries and chambers. Generally speaking, there are from one to four openings to each nest. The writer has never observed a nest with more than four openings. Perhaps the average is about three. I have repeatedly noticed that nests in the desert and semi-desert regions contain a greater number of openings than those in less arid environments. This may be due in part to the number of individuals composing the colonies or to the temperature and moisture conditions of the habitat, or both.

The nest chambers were usually found about 18 inches below the surface of the ground and apparently varied in

[1]Wheeler, W. M., *Ants, their structure, development and behavior*, Columbia Univ. Press, New York, 1926.
[2]Ibid., p. 201.

number with the numerical strength of the colony. They harbored the brood, all stages being mixed regardless of age. In some of the chambers various seeds were stored with the brood. Even the superficial chambers at the surface occasionally contained mixed seeds. It would seem from this that *subpolita* might possess granivorous as well as carnivorous and secretivorous[3] habits. However, no ants were found carrying seeds into the nests, a process which must be observed before a granivorous habit can be correctly assigned to the species. One or more of the superficial chambers usually contained parts of dead insects which had apparently been rejected by the ants. The superficial chambers sometimes contained brood of various ages, and even winged adults in some cases. In the vicinity of Twin Falls, Idaho, "desert pearls," or "earth pearls," an undertemined species of coccid, were in the surface chambers.[4] This is apparently the first record of their appearance in ant nests of the United States and certainly in those of *F. subpolita*.

The queens, which, in the vicinity of Twin Falls, migrate during early July, dig small surface chambers under rocks and there deposit eggs. Only when workers have emerged is the size of the formicary increased. The nest, has, at first, only one entrance but later may contain three or four, as mentioned above. Thus the incipient nest is nothing more than a small chamber under a rock. This chamber apparently remains, and in its original condition, even after the formicary is fully developed.

Cockerell[5] reports that *Elasmosoma vigilans* is a parasite of *Formica subpolita*, in Colorado, and *F. subpolita* has been taken as a slave of *F. pergandei*, *subintegra*, and *puberula*.[6]

The assistance given to this problem by Miss Marjorie Romaine, Bureau of Plant Industry, United States Department of Agriculture, is greatly appreciated by the writer.

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[3]I suggest the term "secretivorous" for those ants which feed upon the secretions of aphids, coccids, membracids, etc.

[4]These have been reported from ant nests in St. Vincent and South Africa by Guilding, B. A., "An account of Margarodes, a new genus of insects found in the neighborhood of ants'-nests," *Trans. Linn. Soc. London*, XVI, (1829), 115–119; and by Trimen, R., "Notes on insects apparently of the genus Margarodes, Landsd.-Guild., stated to occur abundantly in the nests of white ants and also of true ants in certain western districts of the Cape Colony," *Trans. Ent. Soc. London*, (1886), 471.

[5]Cockerell, T. D. A., "A new Braconid of the genus Elasmosoma," *Proc. Ent. Soc. Wash.*, X, (1908), 168–169.

[6]Wheeler, W. M., op cit., p. 460.

A COMPARISON OF THE ALIMENTARY CANALS OF THE ACTIVE AND HIBERNATING ADULTS OF THE MEXICAN BEAN BEETLE, EPILACHNA CORRUPTA MULS.

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INTRODUCTION.

The Mexican Bean Beetle (*Epilachna corrupta* Muls.) is a serious pest of beans, and unlike other members of the Coccinellidae is entirely phytophagous in habit. The beetle hibernates as an adult under leaves, pine-needles, grass, and the like.

The following results represent an attempt to describe the differences in histological structure that occur during the hibernating stage of the beetle.

THE GROSS ANATOMY.

Active adult.—The alimentary canal of the Mexican Bean Beetle is a much convoluted tube running from mouth to anus, and is approximately three times the length of the body. It is divided into three main divisions, the fore-intestine (stomodaeum), the mid-intestine (mesenteron or ventriculus), and the hind-intestine (proctodaeum). (Fig. 1).

The fore-intestine arises as an invagination of the ectoderm, the germ layer from which the hypodermis of the body wall is derived. It consists of pharynx, oesophagus, and crop, no gizzard being present. It is about 2 mm. in length.

The pharynx is a short tube, scarcely 0.15 mm. in diameter, and connects the mouth with the oesophagus.

The oesophagus extends from the pharynx to the crop, the posterior limit reaching the region of the mid-portion of the prothorax. It is but little larger in diameter than the pharynx, measuring on the average about 0.25 mm. The only essential difference between the pharynx and the oesophagus is size.

The crop appears as a small bulb which is slightly larger in diameter than the oesophagus. It is marked at the anterior end by the oesophagus and at the posterior end by the oesophageal valve.

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[1]The author wishes to express his appreciation to Dr. C. H. Kennedy of the Entomology Department of the Ohio State University, under whose direction this work was carried on. He also wishes to acknowledge the helpful suggestions and criticisms of Mr. B. J. Landis of the Bureau of Entomology.

The material for this study was kindly furnished by Dr. N. F. Howard of the Bureau of Entomology.

The oesophageal valve denotes the division between the fore-intestine and the mid-intestine and is indicated by a constriction of the stomodaeum. The valve lies in the region of the posterior sector of the prothorax.

The mid-intestine arises embryologically as an endodermal sac from the proliferation of rings of endodermal cells, one around the posterior end of the fore-intestine, the other around the anterior end of the hind-intestine. The mid-intestine is the longest of the three main divisions of the tract, measuring 9–10 mm. It is divided into two distinct portions, the anterior and the posterior portions of the ventriculus.

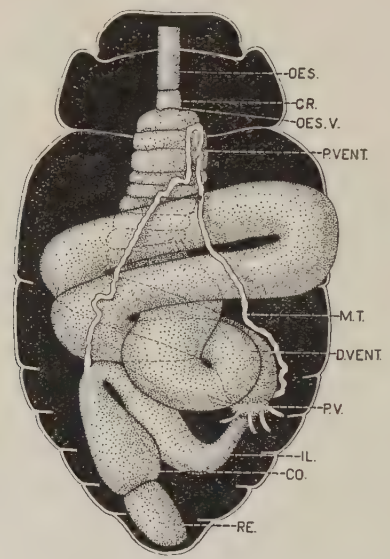

FIG. 1.

Gross dissection of alimentary canal of the active adult of the Mexican Bean Beetle. OES., oesophagus; CR., crop; OES. V., oesophageal valve; P. VENT., anterior portion of ventriculus; M. T., Malpighian tubule; D. VENT., posterior portion of ventriculus; P. V., pyloric valve; IL., ileum; CO., colon; RE., rectum.

The anterior portion of the ventriculus measures 0.75–1.0 mm. in diameter and is characterized by a series of eight or more pseudo-segments. This area comprises about one-third of the mid-intestine.

The posterior portion of the ventriculus is marked by the gradual diminishing of these emarginations and caudad by the pyloric valve. It is in this section of the alimentary canal that the greatest convolution and doubling of the tract occurs. This part of the ventriculus is perhaps slightly smaller than the anterior portion and gradually diminishes in size to the valve.

The hind-intestine arises from the same germ layer as does the fore-intestine, and in the adult beetle is approximately 6 mm. in length. It is divided into four regions, the pyloric valve, the ileum, the colon, and the rectum.

The pyloric valve is distinguished in gross dissection as the point of origin of the six Malpighian tubules. These arise as spokes of a wheel, take a winding course up the mid-intestine as far as the crop, retrace themselves, and apparently return into the tract at the anterior part of the colon.

The ileum is bounded by the pyloric valve at the front and by the colon at the rear. It has a length of 2.5 mm. and a diameter scarcely over 0.25 mm.

The colon links the ileum and the rectum. Its anterior boundary may be recognized by the re-entrance of the Malpighian vessels into the tract. It is 2 mm. in length and slightly pear-shaped, its greatest diameter at the caudal portion being 0.75 mm. The six Malpighian tubules that enter may be seen to follow a winding course under the

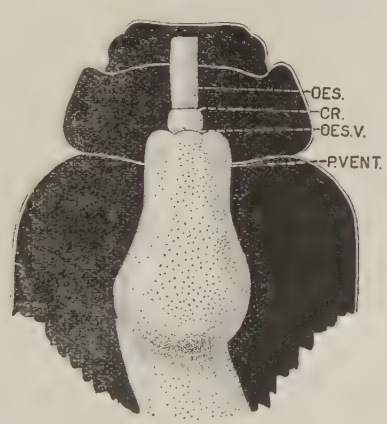

FIG. 2.

Gross dissection of the anterior portion of the ventriculus of the hibernating Mexican Bean Beetle. OES., oesophagus; CR., crop; OES. V., oesophageal valve; P. VENT., anterior portion of ventriculus.

peritoneal membrane down the entire length of the colon, the greatest meandering taking place near the rectum where they terminate.

The rectum is about half the width of the widest part of the colon, slightly barrel-shaped and only 1.0 mm. long.

Hibernating adult.—The fore-intestine is not different in gross structure from that of the active adult.

The anterior portion of the ventriculus, however, loses its segmented appearance, becoming greatly bulged and apparently very thin walled. This bulging effect varies in different specimens, the measurements ranging from 1.5–2.5 mm. at the widest point. This effect seems to be restricted to the first region of the mid-intestine in specimens taken from hibernation quarters in January, 1930, at Columbus, Ohio. Whether this would hold true in specimens taken later in the season of hibernation is not known. (Fig. 2).

Beginning at the posterior portion of the ventriculus, the size of the tube gradually decreases and becomes thread-like, continuing thus in

miniature throughout its entire length, the different parts still holding their gross morphological structure.

This thread-like appearance is even found in the Malpighian vessels, which become very minute.

HISTOLOGY OF THE ALIMENTARY CANAL.

FORE-INTESTINE.

Active adult.—Throughout the fore-intestine there is a similarity of structures in its various parts. From the inside outward, the following structures appear:

1. Intima, or Cuticula of chitin, which is directly continuous with the cuticula of the body wall.
2. Epithelium of hypodermal cells.
3. Basement membrane.
4. Longitudinal muscles.
5. Circular muscles.

The intima is secreted by the hypodermal cells and is rather a thin, non-cellular, almost transparent layer which lines the whole fore-intestine. The layer of chitin in the pharynx, however, is thicker than in the other parts of the fore-intestine. (Plate I, Fig. 1).

Potts (1927) states that the intima of the oesophagus possesses teeth, but in this study, after examining many sections of this region, no teeth or spines were found. (Plate I, Fig. 7). In the crop, however, the intima is lined with rather long, stout spines, pointing, for the most part, caudad. These, in the absence of the gizzard, are probably used to grind up the food and help it on its way into the mesenteron.

The epithelium of the fore-intestine is continuous with the hypodermis. The cells are very small, the cell walls not always being clearly defined.

The basement membrane is not easily distinguished.

Outside the basement membrane are isolated bundles of longitudinal fibers.

Surrounding the longitudinal muscle fibers is a more conspicuous layer of circular muscle fibers.

The crop appears as a bulging of the fore-intestine into a pouch (Plate I, Figs. 1, 3). The wall makes a fold, forming a double pocket, the entire lining of the crop being stoutly spined. The epithelial layer is not as distinct as in the other parts of the stomodaeum, but the part is more heavily muscled. Many strands of longitudinal muscles are attached to the pockets and terminate in the lips of these oesophageal valves. These, with the aid of the circular muscles, motivate the expansion and contraction of the crop, driving the food materials through the valve and into the stomach.

The oesophageal valve is formed by the protruding of the fore-intestine into the lumen of the mid-intestine, the projection folding back on itself in such a way as to form lip-like structures. (Plate I, Fig. 1). This reflected surface joins the wall of the mesenteron. It is at this point that the chitin of the stomodaeum disappears. The epithelium layer of the fore-intestine once more comes into prominence

at the cephalad portion of the valve, the cells becoming larger as the tip of the valve is reached. At the point most caudad in the lips of the valve, the longitudinal muscles are anchored, connecting this portion with the out-pocketings of the crop. Immediately outside this layer are numerous bundles of circular muscle fibers. This region is very heavily muscled, probably for the purpose of grinding and forcing the food into the stomach and preventing, by the contraction of the circular muscles in the valve, the regurgitation of predigested food.

At this junction of the fore- and mid-intestine the longitudinal muscles cross over the circular muscles.

Hibernating adult.—There are no differences in the histological structure of the fore-intestine in the active adult and in the hibernating form.

The Mid-Intestine.

THE ANTERIOR PORTION OF THE VENTRICULUS.

Active adult.—The anterior portion of the ventriculus consists of about one-third of the total mid-intestine, and is characterized by a series of folds, eight or ten in number. In gross dissection, they appear as segments of the intestine, but in section they show up as annular invaginations. (Plate II, Fig. 3).

The structure of the mid-intestine is markedly different than that of the fore-intestine. There is no chitinous intima, that structure being lost at the oesophageal valve. The layers of the mesenteron from the inside outward are as follows:

1. Intima, not chitinous.
2. Epithelium.
3. Basement membrane.
4. Circular muscles.
5. Longitudinal muscles.
6. Peritoneal membrane.

It will be noted that the circular muscle and the longitudinal muscle layers have changed position, the longitudinal muscle being on the outside.

The food of the stomach is always enclosed in a thin, elastic membrane known as the peritrophic membrane, which holds the food together in a compact cylindrical mass. This membrane is probably not chitinous but a secretion formed at the surface of the epithelial cells.

The epithelium layer is composed of elongate, columnar cells, closely following the folding of the tract and giving it its annular segmented appearance. (Plate II, Fig. 3). The inner surface of these cells possess a striated border.

Folsom and Welles (1906) in their paper on the mid-intestine of Collembola say in part, "The intima, or lining membrane, is a secretion of the stomach. It is striated transversely. . . . . They are due in all probability to minute pore-canals, through which fluid may be either secreted or absorbed. Frenzel, Oudemans, Somner, Gehuchten and others have described and figured the intima as a layer of fine filaments, to which they gave the name of 'Harchensaum.' In *Tomocerus*, however, the intima presents no such appearance, but it is clearly a

membrane." So is it with the Bean Beetle, a membrane lining the epithelial cells that projects into the lumen of the gut. This layer is not always the same thickness throughout the mid-intestine, but becomes thinner in some parts.

Between the basement membrane and these epithelium cells are groups of replacement cells or nidi. In a cross section, as many as thirty of these replacement cell nests may be present. They are located on the basement membrane and extend up towards the lumen of the stomach, being surrounded by the epithelial cells. (Plate II, Fig. 1). These nidi do not fall beneath the muscle layers as is the case in many Coleoptera. They are specialized for the formation of new cells to take the place of those that are destroyed by secretion.

Surrounding the nidi, underneath the basement membrane is situated a rather prominent layer of circular muscles.

The longitudinal muscles lie in isolated strands outside the circular muscle layer.

Hibernating adult.—In the hibernating beetle an altogether different condition exists in the fore part of the mid-intestine. There appears a curious splitting of epithelial tissue that closely resembles the one found by Folsom and Welles (1906) in Collembola during the moulting periods.

In the extreme anterior portion of this region, the only evidence of this condition is the distended and structureless remains of the original epithelial layer. It is this part of the intestine that gives the swollen, thin-walled appearance in the gross anatomy. (Plate I, Figs. 5, 8).

In order to understand this condition, it is necessary to describe a section taken farther down the canal showing all the structures involved in this degeneration of epithelial tissue.

The food material in this part is surrounded with a peritrophic membrane, the food in this case being partly digested cells, distinguishable by the nuclei that are apparently the last part of the cell contents to become disintegrated. (Plate I, Fig. 2).

The fact that they are cells that are undergoing degeneration and not food particles from other sources is borne out by the absence of a striated border on the cells that now are around the lumen of the gut.

The cell walls of this inner layer of epithelium are not clearly defined, but the arrangement of the nuclei and the remains of cell walls clearly denote that this layer has been cut off from the layer just beneath it.

This inner layer of epithelium also has a thin peritrophic membrane surrounding it.

The remaining structure of the original or outer epithelium layer is very difficult to distinguish. It is a very thin layer, almost structureless, containing a few scattered nuclei. The cell walls are scarcely visible, the whole structure resembling a ring of almost homogenous cytoplasm, dotted here and there with a nucleus.

The remains of nidi may be seen in a few places. They have become very reduced in size and discernible only at scattered points in the sections.

Around the very thin basement membrane is a fine band of circular muscles, surrounded by scattered strands of longitudinal muscles.

It is this thin outside epithelial layer that remains in the extreme cephalad portion of the region. This part of the stomach contains no food materials of any sort, appearing in cross section as a thin, inflated ring. The absence of food in this region would suggest that after the disintegration of the cells at this point, they move down the tract, either becoming digested or stored, to be excreted when the beetle comes out of dormancy.

THE POSTERIOR PORTION OF THE VENTRICULUS.

Active adult.—The posterior portion of the ventriculus is characterized by the absence of the annular pseudosegments.

The layers of this portion of the ventriculus are similar to those of the anterior portion, the difference being in the shape of the epithelial cells.

The epithelial cells in this area are simple columnar and are much shorter than those of the preceding region.

At the caudal end of the posterior portion the epithelial cells again lengthen out until at the pyloric valve the cells almost entirely fill the lumen of the gut. (Plate I, Fig. 6).

In this region of the mid-gut it is possible to study the replacement of cells by nidi. (Plate II, Fig. 2). It appears as if each nidus replaced cells from a certain restricted area, making a line of demarcation between the replaced cells of one nidus from another. The nidi are small, rounded structures containing many nuclei, those on the border of the nidi towards the epithelial layer being somewhat flattened. The newly formed cells from these replacement nidi are small, flask-shaped structures. These cells are laid down alternately, each nucleus coming to the surface of the nidus and then becoming sloughed off, the axis being at the outer borders of the nidus. These new cells continually grow in size until they have reached the lumen of the gut. These cells contain many large vacuoles which, combined with the great rapidity in the replacement of cells, tend to show that a great deal of the secretion of the mid-intestine takes place in the region just anterior to the pyloric valve.

Hibernating adult.—This region of the mid-intestine of the hibernating adult also supports the marked change in structure from that of the active insect. It is very similar to that of the preceding hibernating region except that the outer epithelial layer is much thicker, and the cell walls are much more visible. (Plate I, Fig. 4).

Folsom and Welles (1906) consider this degeneration of epithelium tissue as an excretory function in Collembola. In the Mexican Bean Beetle that can hardly be the case, but it is possible that it is a mechanism to keep the animal nourished during its hibernation period by consuming its own cell body!

SECRETION.

Active adult.—In the insect world there are two distinct types of secretion, merocrine and holocrine. Merocrine is defined in *Stedman's Medical Dictionary* as, "Noting a gland, the product of which is secreted by the cells, the latter not being destroyed, such as a mucus gland."

This type of secretion is found in some Dipterous larvae where the digestive fluids are diffused through the cell wall, the cell itself not being destroyed. Holocrine is defined in *Stedman's Medical Dictionary* as, "Noting a gland (1) whose function is purely secretory, or (2) the secretion of which consists of altered cells of the gland, such as a sebacious gland." *Webster* defines the term as, "Wholly used for secretion, applied to those cells whose entire substance is given up as a secretory product." In insects, the latter type seems to be the most common form of secretion in the mid-intestine.

Secretion in the Mexican Bean Beetle is a modified holocrine type, apparently taking place anywhere in the mesenteron, but more especially in the posterior portion of the ventriculus, and gaining its maximum just anterior to the pyloric valve. The cells at the time of secretion do not actually burst and let the contents flow out into the gut, but the ends of the secreting cells become constricted and form balls of digestive fluid, which finally pinch off and allow the globules to become free in the lumen of the stomach. During the process of secretion, the intima remains around the globule until it has been separated from the cell proper. (Plate II, Figs. 4, 7). The intima around the globule is greatly thinned, evidently due to the stretching of the intima. At the time of separation, the intima breaks, leaving but part of a border around the globule. The intima at the breaking points, however, apparently reunites and leaves the secreting cell intact except for its loss of cell contents through the process of secretion. In no case was the nucleus of the secreting cell found in the globule that was secreted.

These globules become less definite in outline as they reach the food body in the center of the lumen.

The secreting cells of the epithelium in the mid-gut are long and turgid with the secreting substance, becoming convex at their free surface. In the secreting cells large vacuoles occur, supposedly containing the digestive materials.

Replacement cells or nidi are very prevalent in the mid-intestine, suggesting that the secretory cells become functional, secrete, discharge, digest, and die, giving their places to new cells which arise from the nidi.

Hibernating adult.—There is no evidence of secretion of any type in the adult during hibernation. This is not to be expected, as during dormancy the adult does not feed.

The Hind-Intestine.

Active adult.—The hind-intestine consists of four parts, the pyloric valve, the ileum, the colon, and the rectum. The tissue layers are the same in all parts, namely:

1. Intima of chitin.
2. Hypodermal epithelium.
3. Basement membrane.
4. Circular muscles.
5. Longitudinal muscles.
6. Peritoneal membrane.

The Malpighian vessels arise just caudad from the end of the mid-intestine and cephalad from the pyloric valve. There are six tubules arising as the spokes of a wheel around the intestine. The epithelial cells at the origin of the tubules are cuboidal in shape and are very small in comparison to the cells of the mid-intestine. (Plate I, Fig. 6).

The pyloric valve is very well developed. Grossly, it is a long structure placed in the tract in a manner similar to that of the "sections" in an orange. There are six of these "sections" and when viewed in cross section they appear as six lobes extending into the lumen of the hind-intestine. (Plate II, Fig. 5). These ridges occur in one form or another all along the proctodaeum.

The layer of chitin is well developed in the pyloric valve.

The epithelium layer consists of rather tall columnar cells closely following the invaginations of the basement membrane.

The most prominent layer in the pyloric region is the layer of circular muscles that is found outside the basement membrane. This layer of muscle is probably the most outstanding muscle layer in the whole alimentary canal, the only other region so greatly muscled is the rectum.

Outside the circular muscle layer are found isolated strands of longitudinal muscles.

The ileum still possesses the vestiges of the lobes of the pyloric valve. The epithelium cells, however, have lost their columnar type, becoming cuboidal. (Plate II, Fig. 8). The circular muscle has reduced in number of fibers, being only approximately half as many as in the pyloric region. This is bordered by isolated strands of longitudinal muscles.

The colon is marked by the entrance of the Malpighian tubules under the peritoneal membrane. (Plate II, Figs. 10, 11.)

The epithelium layer is similar to that of the ileum, though not quite as pronounced.

Outside the basement membrane is an insignificant layer of circular muscles. The longitudinal muscles are not easily distinguishable.

The most striking thing about the colon is the appearance of the Malpighian tubules under the peritoneal membrane. The Malpighian vessels usually consist of a tube, four-celled in cross section, and in the region of the hind-gut the inner border of the tubule is striated. (Plate II, Fig. 6). These vessels enter the small end of the colon as six separate tubules, and follow a fairly straight course down the colon to the point where it begins to bulge. Where the bulge begins, the vessels begin a series of folds or convolutions. At no point in their course do the tubules enter the hind-intestine, but wind their way under the outer layer down to the rectum where they come to an abrupt termination. (Plate II, Fig. 12). The winding of the Malpighian vessels under the peritoneal membrane explains the occurrence of more than six sections of tubules in some slides, some single tubules being sectioned more than once. (Plate II, Fig. 9). At no place do the Malpighian vessels branch.

The chitinous intima of the rectum is heavier and more jagged in appearance than in any other portion of the whole digestive tract. (Plate II, Figs. 10, 13).

The epithelium is indistinct, the cell outlines being very difficult to see. The epithelial layer is still thrown into six longitudinal folds.

The most outstanding layer in the rectum is the heavy layer of circular muscles that is found outside the basement membrane.

The longitudinal muscle layer is indistinct. Isolated strands are sometimes found intermingled with the circular muscles.

Hibernating adult.—There seems to be no difference in the structure of the hind-intestine of the hibernating adult. However, the diameter of this structure in the hibernating adult is much smaller. It usually becomes filled with structureless waste materials which are probably the indigestible remains of food that are held in this region until the beetle becomes active and once more can rid its system of waste substances.

CONCLUSION.

The purpose of this paper is not to solve for all time the changes in the morphology of the Mexican Bean Beetle during its dormant period, but merely to show and attempt to describe some of the histological differences that occur. A true and complete understanding of this phenomenon lies covered in the combined fields of morphology and physiology. Work along these lines would undoubtedly ferret out the causes and conditions under which this epithelial degeneration takes place, as well as describe more in detail the structures involved over the whole period of dormancy. It need not be said that a vast amount of work can be done along these lines, in other hibernating insects as well as in the Mexican Bean Beetle.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1. Longitudinal section of pharynx, oesophagus, valve, and portion of mid-intestine. Active adult.
Fig. 2. Cross section of anterior portion of ventriculus, showing double splitting of the epithelium layer. Hibernating adult.
Fig. 3. Cross section of crop. Active adult.
Fig. 4. Cross section of posterior portion of ventriculus, showing single splitting epithelium. Hibernating adult.
Fig. 5. Longitudinal section of anterior portion of ventriculus. Hibernating adult.
Fig. 6. Longitudinal section of pyloric region, showing posterior portion of ventriculus, Malpighian tubule attachment, and section of pyloric valve. Active adult.
Fig. 7. Cross section of oesophagus. Active adult.
Fig. 8. Cross section of anterior portion of ventriculus. Hibernating adult.

Plate II.

Fig. 1. Cross section of ventriculus. Active adult.
Fig. 2. Cross section of posterior portion of ventriculus, showing replacement of cells by nidi. Active adult.
Fig. 3. Longitudinal section of anterior portion of ventriculus. Active adult.
Fig. 4. Cross section of ventriculus, showing secretion. Active adult.
Fig. 5. Cross section of pyloric valve. Active adult.
Fig. 6. Cross section of Malpighian tubule. Active adult.
Fig. 7. Section showing cell in the process of secretion. Active adult.
Fig. 8. Cross section of ileum. Active adult.
Fig. 9. Cross section of colon, showing Malpighian tubules under the peritoneal membrane. Active adult.
Fig. 10. Longitudinal section of colon and rectum. Active adult.
Fig. 11. Enlargement of portion of longitudinal section of colon, showing Malpighian tubule under peritoneal membrane.
Fig. 12. Gross dissection showing arrangement of Malpighian tubules under the peritoneal membrane.
Fig. 13. Gross section of rectum. Active adult.

ABBREVIATIONS.

Anterior portion of Ventriculus—P. VENT.
Basement Membrane—B. M.
Circular Muscle—C. M.
Colon—CO.
Crop—CR.
Epithelium—EPI.
Food—FD.
Ileum—IL.
Intima—IN.
Inner Epithelium—I. EPI.
Longitudinal Muscle—L. M.
Malpighian Tubule—M. T.
Nidus—NI.
Oesophagus—OES.
Oesophageal Valve—OES. V.
Outer Epithelium—O. EPI.
Peritoneal Membrane—PTL. M.
Peritrophic Membrane—P. M.
Pharynx—PH.
Posterior Portion of Ventriculus—D. VENT.
Pyloric Valve—P. V.
Rectum—RE.
Secretion Globules—S. GL.
Spine—SP.

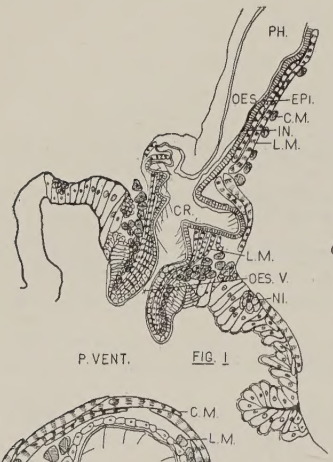
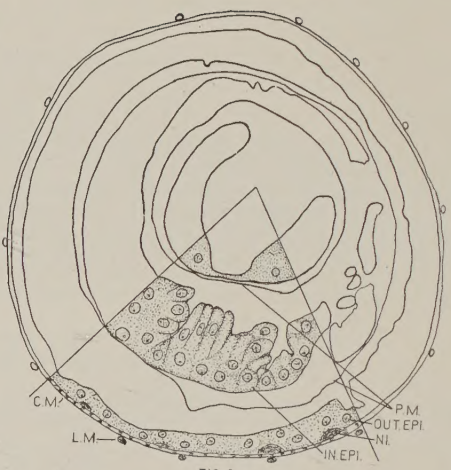


FIG. 1



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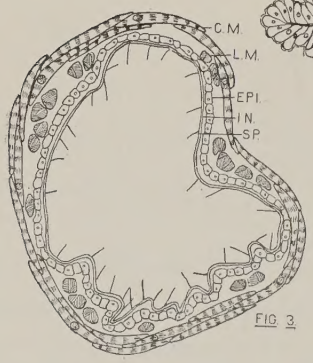

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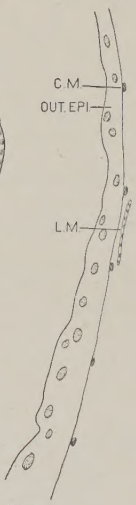

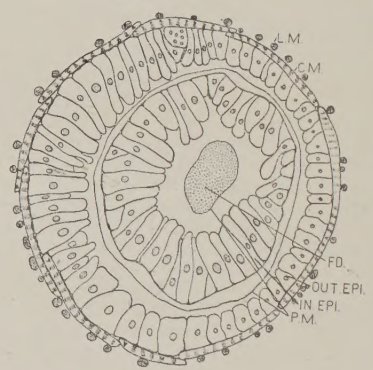

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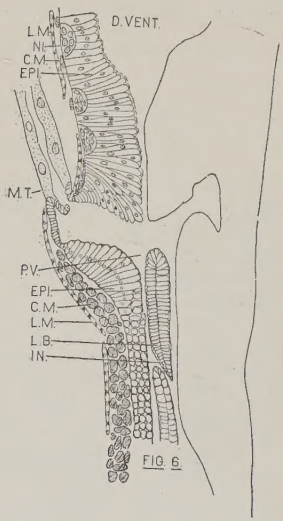

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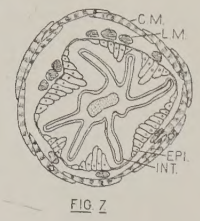

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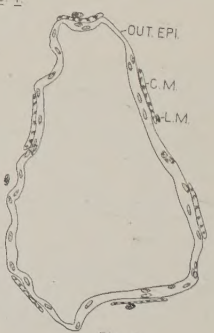

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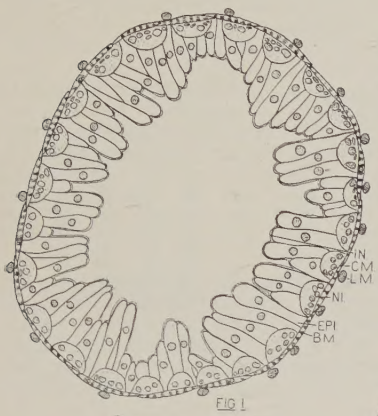

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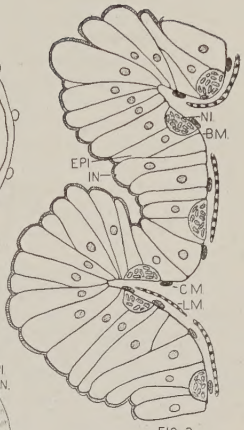

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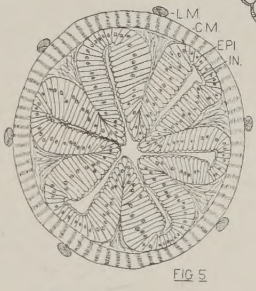

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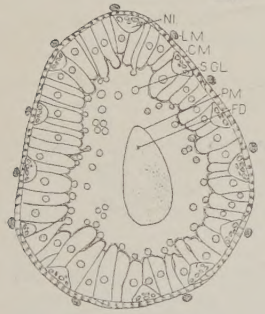

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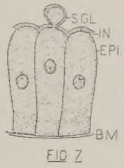
FIG 6



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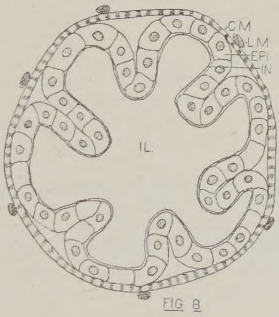

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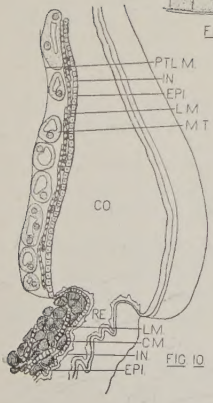
FIG 9



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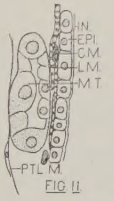

FIG 11

FIG 12

FIG 13

Qualitative Analysis.

This book was first published in 1909, the present revised edition differing from the first edition somewhat in the procedure for getting solid substances into solution, for accomplishing certain cation separations and making certain confirmatory tests using more recently developed methods.

The volume is intended as a brief but adequate treatment of the subject from the modern standpoint and includes sufficient precautionary directions for the student to secure a reasonable delicacy of reaction. So as to stimulate the initiative of the student, very few equations are given. The introductory material is limited to 16 pages, these dealing with: (a) reversible reactions; (b) reactions between ions; (c) dissociation in steps; (d) repression of ionization; (e) equilibrium in a saturated solution; (f) the solubility product; (g) solution; (h) hydrolysis; (i) amphoteric electrolytes; (j) electromotive series; and (k) oxidation and reduction. Students desiring more extensive information are referred to specified pages of Holmes Chemistry and the third edition of McPherson and Henderson's General Chemistry.

Presumably the author presents qualitative analysis as part of a first course in chemistry. It is doubtful as to whether qualitative analysis should in itself be the end in a first course or should merely be a stimulating means to an end—namely, that of a study of the metals and their ions with the non-metals and their ions included so as to give a more completed presentation of elementary qualitative analysis. The reviewer recognizes the fact that most departments of chemistry are service departments and as such are expected to give the students in certain of the professional courses a working familiarity with the procedures and techniques employed in establishing the qualitative composition of the more common inorganic substances.

The author's experience leads him to believe that skeleton outlines of procedure are apt to be followed rather blindly by the student, hence he has given sufficiently full directions and explanatory notes in procedures. This is a meritorius feature of the book. However, it cannot be denied that a much better picture of the relationships within a group of cations is available to the student if a composite procedure is all on one page (or a double page, if necessary).

In several instances a more careful choice or arrangement of words, would enhance the clarity of this Manual. A few examples are: (a) page 4, "NaCl being highly ionized," implies that $BaSO_4$ is not highly ionized; (b) page 11, "Salts of strong acids with strong bases," permits of two interpretations; (c) page 18, "This enables one to work on several parts of an analysis at the same time," (d) page 35, "If bismuth is present it becomes black due to separation in metallic form" (Na_2SnO_2 treatment); (e) "Make first preliminary tests 3;" (f) "Basic Analysis" (Cation Analysis), "Acid Analysis" (Anion Analysis), "Dry Substances" (Solid Substances).

The use of type of different point is generally employed for the purpose of emphasis. On pages 31 and 35, the notes are in smaller type than on page 33, yet all of these are of the same character and of equal importance. Apparently it was the author's desire to have all of the notes on a particular group or sub-group on one page—a feature which warrants some commendation. Frequently suggestions for the teacher and instructions for the student are contained in the same paragraph without even an aside.

Laboratory technique, particularly that involving apparatus, is not pronouncedly stressed, yet the author gives the impression that good technique is essential for rapid dependable work.

There is little evidence for the existence of $\dot{A}s^{\cdot\cdot\cdot}$, $\dot{S}b^{\cdot\cdot\cdot}$, $\dot{S}n^{\cdot\cdot\cdot}$, and perhaps $\dot{A}s^{\cdot\cdot}$ and $\dot{S}n^{\cdot\cdot}$. Ammonia and ammonium hydroxide are sometimes used synonomously—a usage which might be justified as our knowledge of a solution of ammonia in water is limited.

Barring these meticulosities of the reviewer the author has made a worthwhile contribution to the field of introductory qualitative analysis. Many of the books on the market are not only too extensive for students in first year chemistry, but are also too costly to these students—and of this sin the author of this volume cannot be accused.—J. E. Day.

Qualitative Chemical Analysis of Inorganic Substances. Olin Freeman Tower, Ph. D., Hurlbut Professor of Chemistry in Adelbert College of Western Reserve University. Sixth edition revised. P. Blakiston's Son and Co., Philadelphia. xv+92 pp., 1 Fig.+6 Tables, 23.7 × 16 cm. $1.50.